ASSOCIATION BETWEEN STUDENT RELIANCE UPON NO-PENALTY RETAKING OF MODULE TESTS AND FINAL EXAMINATION SCORES IN FLEXIBLY PACED ENGINEERING MECHANICS COURSES

by

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To Marcia and Ann. . . . .

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Abstract of Dissertation Presented to the Graduate Council
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by

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This research investigated a modularized instructional system to determine if there is an association between the extent of retaking of module tests and the score on the final examination of a course. The instructional system consisted of three junior level engineering mechanics courses in statics, dynamics, and strength of materials. The courses were taught at the University of Florida in a flexible modularized form that offered several student options and individualization by student engineering specialty. Several end-of-module proficiency tests were provided for each module. One of these tests was selected at random when requested by a student. A student failing a module test could without penalty retake other tests until mastery of the module was demonstrated. Only the passing grade was recorded. A different

option involving intracourse examinations could be followed by students not selecting or continuing the modular proficiency test option. All students took the same end-of-course examination. No sections of traditionally taught students were available as a control group.

The number of retakes referred to how many times a student attempted to pass a module proficiency test after failing an initial attempt. The number of retakes was used as an independent variable for multiple regression analysis.

Score on the final examination was the dependent variable. Grade-point average and number of retakes were used to predict the observed final examination score. GPA was assumed to be the major determinant. With its effects statistically controlled, the effect of the number of retakes was sought as a second-order effect.

Ten sections of the modularized courses yielded usable data. GPA was a statistically significant predictor of final examination score in six sections. In three of these six sections, the number of retakes was also statistically significant at the 95% level of confidence.

In two of these three cases, an increasing number of retakes was associated with a decreasing score on the final examination. In the third case, the opposite was unexpectedly found to be true. Students who seemingly had difficulty mastering the modules did unexpectedly well on the final examination

Investigation of circumstances relating to the three sections yielded the finding that students in the first two sections frequently took two, three, or in some cases four versions of a module completion test on the same day. Their demonstrated mastery of the subject matter

could reasonably be attributed to happenstance rather than to restudying and increased learning. Moreover, the subject matter was statics, which was the easiest of the three courses. The students were beginning engineering students and many of them were recent transfers from the junior colleges. Circumstances were different for the third section, the one in which greater retaking of module tests was associated with increased achievement. Changes in administrative procedure hindered immediate retaking. Students almost never took two tests of a module on the same day. Moreover, the subject matter was mechanics of materials, which was the most difficult of the three courses. Mastery upon initial studying might well not be expected. The students were more mature. Although this section was small, it yielded a highly statistically significant result that could not be disregarded.

The researcher concluded that there is a small but discernible association between the extent of module test retaking and the score on the final examination of a course. The manner of retaking rather than the amount of retaking appeared to be the condition that influenced end-of-course achievement.

CHAPTER I

INTRODUCTION

Background

Academic course offerings at all levels have tended to change from rigid to flexible formats in recent years. One of the innovations has been the use of modularized packaging of course content. This innovation has provided opportunities for individualization, flexible pacing, and mastery learning. Use of these techniques at the college level has been less extensive than at lower levels.

Three introductory engineering courses at the University of Florida were restructured and offered in a modularized format that permitted self-pacing and a degree of individualization. For a period of approximately two years, an unlimited retaking of randomly selected module tests was permitted, thus allowing students to maintain an average of A or B up to the point of taking the final examination.

Statement of the Problem

The College of Engineering of the University of Florida in 1973 offered three basic undergraduate engineering courses in a modularized form. The three courses were engineering mechanics courses in statics, dynamics, and mechanics of materials and are described in Chapter III. Minor variations in the selection of modules assigned to students provided a type of individualization of course content. These variations

provided a specialization according to a student's major within the several departments of the College of Engineering. Student self-pacing and unlimited retaking of module tests were the main student options provided. This dissertation was undertaken to provide an in-depth study of the no-penalty retaking of module tests. This dissertation primarily seeks to answer the question, Is student use of the unlimited no-penalty retaking of module tests associated with student achievement an the final examination when the effects of other reference or causal variables are statistically controlled? No causal relationship between achievement and extent of module test retaking was hypothesized.

Need for the Study

The modularized sequence of engineering mechanics courses at the University of Florida was implemented after considerable curriculum development effort. The unlimited retaking of module tests without penalty was a feature that had been included because of the belief that it was a desirable liberalization from the previous instructional method. In 1975, this feature was discontinued because reduced funding curtailed personnel services necessary to maintain the testing system.

The question remained open as to the relationship between student achievement and the no-penalty retaking of module tests. This dissertation provided an in-depth investigation of results associated with retaking of module tests. The associations that were found permit prediction of achievement based upon known patterns. Counseling and early remedial guidance can be facilitated.

Assumptions

The assumption of this investigation was that a student's academic achievement is the best predictor of that student's expected academic achievement in other courses under identical circumstances. Achievement in standard courses was used to calculate the expected achievement in other courses taken concurrently. The effects of ability as well as environment were thus assumedly controlled by using known representative achievement during a given time period to estimate an achievement that would be expected in separate courses taken during the same time period. Selections from the literature concerning this assumption are presented in Chapter II.

Definition of Terms

The expression "modified junior year GPA" refers to a specially calculated grade-point average earned in traditionally taught courses taken during the same time period as were the modularized engineering mechanics courses. The normal time for taking these engineering mechanics courses was the junior year. Some students began the course sequence early, during their sophomore year. Other students finished the sequence late, during their senior year. Some students began early and finished late. The many variations required the researcher to select three representative quarters for each student. These quarters were those in which the student took the three engineering mechanics courses or a portion of them. The selected three quarters approximate the junior year time period and are so labeled.

The term "no-penalty" in the expression "no-penalty retaking of module tests" refers to the unlimited retaking of randomly selected

end-of-module tests until a score of 80% or better was obtained. Only this last score was recorded for the module concerned. The scores of previous attempts had no weight in determining the letter grade for the course.

A retaking of an end-of-module completion test occurred after a student failed in his first attempt to pass one of the randomly selected tests. Each subsequent attempt to pass another of the tests for that module was a retake. In an eight module version of a course, a student requiring a total of 10 attempts had two retakes. When used as an independent variable in regression equations, the number of retakes is represented by the capitalized word "Retakes."

This investigation was an associational study. It was not an experiment based on random assignment. A cause and effect relationship was not being sought. Somewhat more general words like "result" and "outcome" were usually used herein in lieu of "effect."

The term "independent variable" referred to the number of module test retakes during a course. The term "dependent variable" referred to a student's score on the final examination of the course. The latter definition was augmented when chi square analysis was used. In that situation, a student's final examination score as compared to his expected score was used as the dependent variable. The standard mathematical terms "independent variable" and "dependent variable" were used in this associational study although some researchers prefer to use these terms only for experiments seeking cause and effect relationships.

Boundaries of this Investigation

A multitude of factors influence or are associated with student achievement. This investigation examined one of these, the number of times individual students relied upon the no-penalty retaking of module tests. This study was limited to those students who took one or more of the three modularized engineering mechanics courses at the University of Florida during the period from September 1973 to March 1975. This study considered only those students who pursued the modular path to completion and did not investigate dropouts or students who chose to follow the alternate path involving scheduled intracourse examinations.

Method

Student achievement is multi-determined. This investigation designated student achievement in the modularized instructional system as the dependent variable. The extent of retaking of no-penalty module tests was one independent variable. The many other influences were grouped into a single variable termed modified junior year grade-point average. Statistical analyses were performed to see if individual student reliance upon the no-penalty retaking of module tests was significantly associated with student achievement when the other influences were controlled. The design and methodology are described in Chapter IV.

Summary

A modularized instructional system was developed and implemented at the University of Florida for three junior level engineering mechanics courses. The effectiveness of the innovations is a relevant

question. An analysis was made of the way that academic achievement of students was associated with an instructional feature allowing unlimited no-penalty retaking of module tests.

CHAPTER II

REVIEW OF RESEARCH AND RELATED LITERATURE

Introduction

An abundance of literature directly relates to predictors of academic success. Because this dissertation compared observed student performance with a calculated expected (predicted) performance, the subject of methods of prediction of academic success is relevant. Selections from the literature are reported herein.

A meager amount of literature relates to flexibly paced modularized courses at the college level. The effects of unlimited no-penalty retaking of module tests in college level courses is an aspect that has seldom been reported.

A computer search of The Educational Resources Information Center (ERIC) showed a listing of 31,238 articles on colleges, universities and higher education of which 1180 related to testing and related index terms such as testing methods. When the index term "modular" or related words were added to those involving "college level" and "testing" for an inclusive search specification, the number of articles decreased to three. The index word "retake" and its variation when used alone produced 10 references of which only two related to college level testing. A character by character stringing was used to produce the composite index term "retake module tests." No articles were found for this term. It is noted that the <u>Thesaurus of ERIC</u>

Descriptors does not list the key words "modular" or "modularized" in uses related to course organization or the key words "retake" or "repeatable" in uses related to testing.

A computer search of dissertation abstracts showed 194 entries having the key word "modular" or "modularized" and 4701 having the key word "test," "testing" or variations. When variations of "modular" and "test" were used together, the number of entries decreased to three, and the subject matter of one of these pertained to the testing of electronic modules.

A manual search of dissertation abstracts and the ERIC system was therefore the primary means of reviewing the literature.

Predictors of Academic Success

Prediction of academic success is one of the most extensively explored areas of educational research. A large number of variables have been investigated for their predictive efficacy. Sophisticated statistical methods with use of computer processing of extensive data have been used.

Of particular interest to this dissertation is its use of a modified junior year grade-point average to estimate expected achievement. Mann (21) found that the best single variable for use in determining admission to a professional engineering program was sophomore grade-point average. His study had examined 26 predictors. Chapman (8) in a study of engineering students found that combinations of several psychometric predictors offered no improvement over prediction by any of his single predictors alone. Of interest to this dissertation is that Chapman's predictors could establish

excellent group distinctions even though individual student predictability was small.

For community college graduates transferring to the University of Florida, Sitzman (31) found that the most powerful predictor of success was the grade-point average earned prior to transfer. Post-transfer variables such as age, marital status, and local residence were included among the predictors tested.

In observing the validity of the 1966 precollege testing program for students who entered Walla Walla College, Wagner (39) found that the test score was a valid predictor of the all-college GPA, especially for female students. The cummulative GPA at the end of the third quarter was better predicted than the final GPA.

Schroeder and Sledge (30) found that intellective variables were better predictors of college achievement than nonintellective variables. Ronald G. Taylor (35) supported the conclusions of many when he found that ability factors were the best determinants of student success in collegiate programs, especially so for academically oriented curricula rather than for vocationally oriented programs.

Stone (33) reported that the first semester grade-point average had a statistically significant relationship with continuance in college. Fairchild (13) found that the total grade-point average was the better predictor of academic performance as compared to grade-point average in the student's major.

For students within the community colleges in the state of Washington, VanDruff (37) found that high school GPA and initial GPA at the community college were the best predictors of success in calculus. Only a few predictor variables were studied. The multiple regression

equations derived were better predictors of the "A" grade or of the no-credit grade than of the intermediate grades.

Another study to determine predictors of success in calculus was conducted by Sommers (32) at Hope College. He related several pre-course factors to the score obtained on the final examination in the calculus course. The best precourse factor found was high school GPA. A locally prepared test as well as the verbal and mathematics scores from the SAT were also found to be valid predictors of success in calculus.

For students transferring as juniors to the College of Engineering at Oklahoma State University, Mouser (23) compared previous academic aptitude variables and previous academic achievement variables to see which better predicted success in undergraduate engineering courses. The previous aptitude variables were scores from the ACT. The previous achievement variables were overall GPA and subject GPA. The findings suggested that previous academic achievement is more closely related to subsequent GPA than aptitude as measured by the ACT. Use of both in multiple regression equations produced the best predictive capacity.

Other studies have reached rather different conclusions about efficacy of predictors of academic success. Elkins (12) showed that the mathematics portion but not the verbal portion of the SAT could discriminate between persisters and dropouts among freshman engineering students at the University of Maryland. In studying achievement in the general educational requirements of lower division college students, Cloninger (9) found that noncognitive factors play an important role in predicting academic success. These factors

accounted for most of the variance between students with respect to the regression equations predicting their achievement.

Comparisons of Various Teaching Methods

Another much researched area is the comparison of two teaching methods. Attempts to reveal significant differences by statistical analysis of observed data often do not indicate a difference of learning effectiveness attributable to teaching method. Some researchers finding this result conclude that student ability rather than teaching method is what matters.

An individually paced instructional system in an engineering college was compared by Venable (38) with group paced classes proceeding in a more traditional manner. The classes involved sophomore engineering courses of statics and dynamics. Twenty-seven programmed instructional units were prepared for each course. The classes taught in the more traditional manner proceeded on a published schedule. Students in the self-paced classes took quizzes available 40 hours per week. Examinations were given in sequence when an individual student was ready. This research found no difference between the instructional methods as indicated by the examination scores. It also showed no clear relationship between the number of attempts which a student in the self-paced classes made on unit quizzes and his examination performance.

Eide (11) studied the effect of two different methods of teaching engineering graphics. His experimental study compared the learning achievement of freshman students in a conventional "lecture and problem" class with achievement of similar students using a

series of 25 learning packages with audio-visual tapes. Students in the latter group could control the amount of time for individual study used to complete a unit. No significant difference in the amount of learning was found between the two instructional methods. High school scholastic achievement was a good indicator of achievement for students using either method.

In another study comparing two methods of teaching engineering graphics, Walker (40) compared the effectiveness of an idea-communication method with that of the traditional method. No significant differences in any of three dependent variables (results) were found. Walker concluded only that students with higher levels of critical thinking ability attained a greater degree of general drafting knowledge than did students with lower levels of critical thinking ability.

Harris (17) compared student performance in a college engineering science course in which students were randomly assigned to classes using one of two different teaching methods. One method used an audio-tutorial approach. The other used a printed transcript of the same material. There was no significant difference between the learning achievement of the two types of classes.

A similar finding was reported by Otten (26) who compared three instructional models for teaching a sophomore electrical engineering AC circuit course. One method used the traditional lecture approach without written objectives or use of computer. A second method utilized measurable behavioral objectives. A third method used the computer as a computational tool to illustrate the material and motivate the students. All three methods were found to be effective. No statistically significant differences in achievement appeared among the groups

instructed by the three different strategies.

A different conclusion was reached by Aird (1) in comparing traditionally taught engineering students with students using self-study involving computer based instruction. Mechanics of solids was the engineering courses taught by the two methods. The findings seemed to justify the conclusion that the computer based instructional mode produced students who performed better than traditionally taught students.

Related to these comparisons of teaching methods is the finding by Tovey (36) that postadmission factors have little influence on performance of incoming high school graduates and that the best predictor of college success is rank in high school rather than postadmission events.

Simarily, a study of the use of repeatable testing for college chemistry students by Donovan (10) revealed no difference in final achievement as compared with the control group students who took nonrepeatable tests.

Compulsory attendance in an audio-tutorial college biology course was compared by Nord (25) with noncompulsory attendance. He found no significant difference in achievement between students participating in the two methods.

Compulsory homework assignments for college mathematics students was compared to no homework assignments in a study by Hasen (18). He found no significant difference between group achievement means.

Comparisons of teaching methods involving self-pacing and mastery learning are included in the following section.

Additional Topics

Self-pacing as well as repeatable testing is a part of the modu-

larized course offerings studied in this dissertation. Bass (4) in his study of engineering graphics taught with self-pacing as compared to the traditional method could reject no null hypotheses and concluded that the new method was similar in effectiveness to the traditional method.

Gallegos (14) investigated pacing and found that forced pacing at a rate greater than students would choose for themselves was less effective than self-pacing or slow prescribed pacing. He found that self-pacing was particularly beneficial for high ability students. On the other hand, slow but prescribed pacing was better for low ability students than self-pacing alone.

Lasco (20) reported that external pacing (self-pacing) caused an increase of student time devoted to study in a learning laboratory but did not affect end-of-course group achievement. His experiment used an individualized instructional system consisting of nine units in audio-tutorial format for the teaching of college level geology. As a student's characteristic work rate became slower, total unit achievement tended to increase but end-of-course achievement did not. As a student's characteristic work rate became slower and in addition his general ability increased, total unit achievement as well as end-of-course achievement tended to increase. The above findings suggest that those engineering students of this dissertation who finished the modules early and hence seemingly without difficulty and those students who progressed mainly by persistence will not necessarily be high achievers on the final examination.

Self-pacing has the inherent disadvantage of permitting procrastination. Some personality types would be expected to be more prone to

difficulties caused by procrastination than other students. Gehlausen (15) analyzed the personality types of beginning engineering students at Tri-State College. Despite many similarities between the successful students and unsuccessful students regarding their backgrounds and interests, the former as compared to the latter were found to have a history of academic success, higher aptitudes, higher expectancies, and better study habits. The high achievers in engineering seem to do less procrastinating, waste less time, have fewer distractions, and in general have better study orientation.

A self-paced instructional system also using an open learning laboratory and repeatable mastery examinations like the instructional system of this dissertation was investigated by Naegele (24). The subject matter was introductory college physics. His findings support Ausbelian learning theory that the most important factor influencing learning is the learner's possession of those concepts and skills which have a clear and direct relationship to the subject matter under consideration.

Mastery learning is important in the instructional system investigated by this dissertation. It is a strategy that permits variations of the kind, quality, and duration of instruction so as to fit an individual's need as measured by frequent evaluations with immediate feedback.

Mastery learning was compared with the traditional method of teaching freshman mathematics in a study by Price (28). He found no significant difference in his experimental study. Student profile did not matter either. It appeared, however, that as students had time to adjust to the mastery learning procedure, their performance on achieve-

ment tests improved. Price felt that the middle ability student in particular reflected this trend.

Caponigri (7) reached a different conclusion in an investigation of mastery learning methods for teaching college statistics. He compared two methods of mastery learning with the traditional lecture and demonstration method. Both methods of mastery learning showed a significant improvement over the traditional method. Nonetheless, even though mastery learning had been obtained, the end-of-course examination scores correlated directly with a precourse mathematics aptitude test. This finding conflicts with the hypothesis that in a mastery learning system the relationship between aptitude and achievement should approach zero.

Rowberry (29) studied an adjunctive auto-instruction method for dental students and found that every student failing a topic of his course but willing to spend sufficient time could achieve mastery by means of the adjunct method. Although failers became achievers, some of the initial achievers failed to retain mastery to the time of a review test. Apparently some of the initial achievers did not review because pressure no longer existed. This indicates that retention is a problem. Of interest to this dissertation is the question suggested by the above that some seemingly best achieving engineering students who finish the modules early with few retakes of module tests may not necessarily perform best on the course final examination.

This dissertation combined junior college transfer students with native university students in the same test population. Wermers (41) compared the achievement of both types within the upper division students at the Urbana-Champaign campus of the University of Illinois.

He found no difference in general between these two types of students.

Similarly, Philip W. Taylor (34) concluded that transfer students at East Carolina University experienced relatively the same difficulties during their junior and senior years as native students.

The student population used for this dissertation was composed almost exclusively of engineering students. These students controlled their own efforts and pace. Achievement was a personal matter and would obviously be influenced by the personality profile of each individual. Brown (6) has studied the personality characteristics of engineering students who succeed. He reports that the successful engineering student sets high goals for himself and is motivated to attain them. He tends to be orderly and self-sufficient. He relies on personal resources rather than looking to others. The engineering student is aggressive and satisfies this drive through personal exploit rather than by engaging in activities which involve group social or political action.

Personality factors were considered by Kirkpatrick (19) for beginning students of electrical and electronics technology students. He investigated how personality traits and personality types (introversion versus extroversion) are related to academic achievement in two different methods of instruction. One method was an individually paced type; the other involved lectures, discussion, and demonstrations for groups of students proceeding at a group pace. A general finding not statistically significant was that the individually paced method was best suited for students with introversion tendencies. Students with extroversion tendencies generally achieved better in the group method. When personality traits such as Order, Abasement, Change and Endurance

were included with personality types, certain grouping were found to be statistically significant. This research like others shows that individual student achievement is multidetermined.

Braun (5) in his study of engineering and engineering technology students supported the contention that the self-concept of individuals is related to their personal behavior and that measurement of this self-concept should be useful as an aid to curriculum choice.

Peterson (27) considered the hypothesis that factors other than those of an intellectual nature contribute to persistence in an undergraduate engineering program. His study concluded that nonpersisters in engineering tend toward greater independence and nonconformity than do persisters. This finding suggests that the self-pacing feature of the instructional system herein would decrease attrition.

A related finding by Augustine (3) was that both persisters and nonpersisters among academically proficient engineering students are frequently dissatisfied with highly structured inflexible engineering curricula.

Student attitude is a matter of interest in applying the findings of this dissertation. A few additional comments about attitude follow.

A secondary finding of the previously reported research by Eide (11) was that freshman engineering students preferred the modularized version of an engineering graphics course and that those students experiencing it had a lower attrition that did similar students taking the traditionally taught version.

A contrary finding appeared in the previously reported research by Venable (38). In his study of certain engineering students, fewer students in a self-paced instructional system completed the courses

successfully as compared with students in regularly scheduled progression through the identical subject matter.

The Arizona State Department of Education (2) sponsored research that reported results of using modularized versions of five vocationally oriented courses at Eastern Arizona College at Thatcher. Included were engineering related courses in drafting and in electronics. One conclusion was that students liked the ability to finish a self-paced modularized course early but disliked the lack of instructor pressure in setting deadlines.

Student attitude is a matter of interest in applying the finding of this dissertation. In the use of repeatable tests in college chemistry, the previously reported research by Donovan (10) concluded that students feel they learned in the process of repeating a test, that pressure was relieved, and that cheating was reduced. Students did not mind the extra work if an improved grade seemed to be almost a certainty.

Student attitude concerning attendance at lectures was reported by Nord (25), whose research has been previously mentioned. He stated that students who had attended a noncompulsory attendance version of a college course recommended use of noncompulsory attendance far more than did students who had taken the compulsory attendance version.

Harris (17) in his previously reported comparison of two methods of media supplements to engineering courses found that students preferred to have both options available. One method involved an audio-tutorial approach and the other used printed transcripts.

The previously discussed research by Otten (26) measured attitude among students proceeding in three versions of an engineering course.

No statistically significant difference in attitude attributed to the method of instruction were shown to occur among the three groups of students.

Various researchers have selected a multitude of variables that offer promise of predicting academic achievement. Harding (16) used multiple regression analysis to examine 38 endogenous (in school) and exogenous (out of school) variables to determine their ability to predict academic achievement of students at Illinois State University. High school rank and ACT scores were the preadmission variables that had predictive value. For students already in college, those who had greater than average amounts of class cutting or participation in athletics and recreation or in television watching tended to have lower grades. Students who spent greater than the average amount of time with members of the administration tended to have lower grades, but students who had more than the usual amount of out of class contact with faculty members tended to have higher grades. This research illustrates that student achievement is multidetermined.

Regression equations are used in the analysis of this dissertation. In the use of regression equations to predict academic success of Tennessee community college transfer students, McCook (22) found that a separate regression equation was necessary for the graduates of each community college. Similarly, Mouser (23) found predictive capacity was improved when engineering transfer students from two year and four year colleges were considered separately when using regression procedure.

Summary

The literature reports many efforts to predict academic success of individual students. Tests, accumulated grade-point averages, and noncognitive factors have been investigated. Various degrees of success have been obtained in various situations. A previously accumulated grade-point average, usually an overall GPA, has often been found to be a valid predictor and the best predictor of future academic success.

Referring to upper division matriculation the literature suggests that the differences between transfer and native students are small. For college level courses little has been published about the effect of no-penalty repeatable testing in self-paced modularized courses. Investigations of student attitude suggest that students prefer to have alternative methods of learning available.

CHAPTER III

THE MODULARIZED INSTRUCTIONAL SYSTEM AND THE TEST POPULATION

Introduction

This chapter outlines the instructional system which served as a base for this study. The courses, their flexible packaging, the institutional setting, and the student body are described. This chapter outlines the general procedures used for selecting appropriate students to form a suitable base for statistical analysis.

The Modular Instruction System

The College of Engineering of the University of Florida has developed a modularized curriculum for three junior level introductor engineering mechanics courses taken by most undergraduate engineering students. These engineering core courses are Statics (ESM 301), Dynamics (ESM 302), and Mechanics of Materials (ESM 303). They are referred to herein as the ESM courses.

The integrated modular instructional system was developed during the 1972-73 academic year by Professor Martin A. Eisenberg, Ph.D., of the Department of Engineering Sciences. Beginning in the 1973-74 academic year, the modularized system was offered to students in lieu of the traditionally taught versions of the three courses. The modularized versions were the primary instructional mode but scheduled

examinations were available as an alternative to the end-of-module tests. During its inception and initial use, the module system provided for self-pacing and unlimited no-penalty retaking of module tests. As the system evolved, various incentives were used to control the self-pacing feature in order to discourage procrastination. The no-penalty retake feature remained essentially constant until the spring quarter of the 1974-75 academic year. During the preceeding six quarters, the instructional system for all three courses was in full operation with unlimited use of the no-penalty retaking of a randomly selected version of each module test. The data accumulated during these six quarters were used for this research. The basic design philosophy and outline of the system prior to April, 1975 is herein called "the instructional system."

A detailed description of the instructional system was published in the article "A Modular Instructional System For Introductory Courses In Engineering Mechanics" by Martin A. Eisenberg, Ph.D., designer of the system. This article was published in the December 1975 edition of Engineering Education and is reproduced in part in Appendix A. A brief description of the instructional system is presented in the following paragraphs.

The instructional system during the period of data collection employed a flexible combination of modular curriculum packaging, unlimited retaking of module tests, variable pacing, programmed learning materials, and computer management of records.

There were 13 degree programs offered by the several departments of the College of Engineering. The instructional system content was designed to accommodate varying department objectives. Thus an elec-

TABLE 1

MODULES OF THE VERSIONS FOR VARIOUS DEGREE PROGRAMS

Degree program	Course version 301	302	303	Module number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Aero.Eng.	10	22	33	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2		3	3	3	3	3	3	3	3	3	3	3		
Agric.Eng.	10	21	32	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2		2	3	3	3	3	3	3	3	3	3		3		3
Chem.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				
Civil.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				
C.I.S.	12	24		1	1	1	1	2	1	2	1		1	1	1	2	2	2	2	2	2				1	1	1	2	2		2	2	2				
Elec.Eng.	11	20	31	1	1	1	1	1	1	3	1	1	2	2	2	2	2	2	2	2	2	3			3	3	3	3	3		3	3					
Eng.Sci.	10	22	33	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2		3	3	3	3	3	3	3	3	3	3	3		
Env.Eng.	12	24		1	1	1	1	2	1	2	1		1	1	1	2	2	2	2	2	2				1	1	1	2	2		2	2	2				
Ind.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				
Mech.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				
Matls.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				
Nuclr.Eng.	10		34	1	1	1	1	1	1	1	1	1													3	3	3	3	3	3	3	3	3			3	
Syst.Eng.	10	20	30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2				3	3	3	3	3	3	3	3	3				

1 indicates module is part of ESM 301
2 indicates module is part os ESM 302
3 indicates module is part of ESM 303

Versions 10, 21, 22, 23, 31, 32, 33 and 34 are four credit hour courses
Versions 11, 20 and 30 are three quarter hour courses
Versions 12 and 24 are five quarter hour courses

trical engineering student and a civil engineering student did not take the identical modules of ESM 301, Statics, nor did they receive the same number of credit hours.

Table 1 shows the content of courses required for each of the undergraduate degree programs. As far as the University registrar was concerned, there were only three variable credit courses in which the student could enroll. Within each of the courses, however, students could be enrolled in one of three to five different subcourses whose existence was of no concern to the registrar. A study of the content of subcourses 30, 31, 32, 33, and 34 of ESM 303 shows similarity. Subcourse 33 taken by aerospace engineering students differed from subcourse 30 only in the addition of shear center and column buckling modules to the curriculum. Subcourse 34 taken by nuclear engineering students included stress and deformations in thick-walled cylinders under thermal and pressure loading, subcourse 31 taken by electrical engineering students included damped vibrations of particles and rigid bodies. The differences among most of these subcourses was small.

Individualization by student major caused a variation in the choice and number of modules to be included in the three basic course packages. Table 1 previously shown provides the details. A summary of the individualization by major is provided in Table 2. Versions 10, 20, and 30 were applicable to a greater number of students than were other versions.

Five professors taught the courses. A greater number of student assistants staffed the learning laboratory and administered the tests. The professors kept the records of individual student scores made on the final examination of each course. These scores were the dependent variable of this investigation. The student assistants recorded the

TABLE 2

NUMBER OF MODULES REQUIRED FOR INDIVIDUALIZATION BY SUB-DISCIPLINE

Course	Version	Number of Modules
301	10	9
	11	8
	12	12
302	20	9
	21	11
	22	11
	24	11
303	30	9
	31	9
	32	11
	33	11
	34	10

results of individual module tests. Scores of 80% or above were recorded numerically. Scores of below 80% were recorded as F for failure. The module test number, the result and the date were the three kinds of information recorded. The student record sheet used is shown in Appendix B. The recording was in handwriting. Scores of units passed were transferred to a computer. Record of units attempted but failed appeared at no other place than on the student record sheet, which was stored with the module test and work papers in individual student folders filed in the learning laboratory.

In addition to a standard textbook for the courses, students used

a set of programmed study guides. The study guide provided a learning activity package. For each module there was a description of the content and rationale for study of the prescribed material, a statement of prerequisites, a list of behaviorial objectives, a commentary and guide to the text, and a sample proficiency test. An example of a sample proficiency test is shown in Appendix C.

The end-of-module test taken by the student was similar in level of difficulty to the sample test. During the time period of interest, there were five to ten separate end-of-module tests for each of the 34 modules. When ready to take an end-of-module test, a student went to the learning laboratory and was given a test selected randomly from the several for that module. If the student made below 80%, he failed and could then take another of the tests when he so desired. Upon obtaining a grade of 80% of better, the student proceeded to the next module. Only the final grade was counted in determining the letter grade for the course. The algorithm for computer calculation of this letter grade was changed from time to time. The letter grade is not relevant to this research. All students simultaneously took an end-of-course final examination.

The self-paced feature of the instructional system was designed to cater to the broad range of input student competencies. As originally implemented, the system employed a significant element of flexible pacing strategy. Major traditional examinations were scheduled during the fourth and eighth weeks of a ten-week quarter. Students had the option, however, of demonstrating proficiency by passing the related module tests prior to the dates of these two scheduled examinations. Students demonstrating A or B proficiency as indicated by

grades of 80% on the module tests were excused. This feature was to discourage procrastination. The details of this feature varied somewhat during the evolution period of the instructional system.

The learning laboratory staffed by student assistants provided tutoring help in addition to administering the module tests.

The Test Population

The undergraduate engineering students who comprised the total population had different types of educational institution backgrounds prior to beginning the introductory courses of engineering mechanics. The two main sources of students were the junior colleges and the University College of the University of Florida. A few students came from other universities. Thus the three general types of students within the test population were native students and two types of transfer students.

University College students begin as freshmen at the University of Florida. At approximately the end of the sophomore years, students transfer to the various upper division colleges such as the College of Engineering. Some of these native students begin the junior level engineering mechanics sequence of courses during their sophomore year.

Junior college graduates who transfer to the University as engineering students begin as juniors. Such students have completed their general educational requirements and have been awarded the Associate of Arts degree. Most of these students come from the 28 Florida public junior and community colleges. Some native and transfer students do not initially register for the engineering mechanics course sequence and therefore begin the sequence late.

Students from other universities who transfer to the University of Florida as engineering students are sometimes well beyond completion of the sophomore year and occasionally have some type of baccalaurate degree.

The test population consisted of those students selected from the total population. The total population consisted of all students who took any of the three modularized engineering mechanics courses from September 1973 through March 1976, in which unlimited no-penalty retaking of module tests was permitted. Various types of native and transfer students participated as described above. The following paragraphs describe the selection of students who were included in the data base of this investigation. Uniformity of situation and completeness of data were the two general considerations used to select those students who were included in the test population.

Students who took few other courses concurrent with the modularized engineering mechanics courses accumulated too small a number of credit hours to provide a reliable measure of their level of achievement. The researcher set 20 usable hours as a minimum for providing a reliable average, defined as the modified junior year gradpoint average. Very few students were eliminated from the test population by this criterion.

Students participated in part or all of the three course engineering mechanics sequence during other times than their junior year. Students who began in the last quarter of their sophomore year or who completed by the end of the first quarter of their senior year were considered by the researcher to have been in the standard time sequence. Their data were combined with that of students who were

juniors at the time they took the courses. A considerable amount of data would otherwise have been deleted. After review of the transcript of each student, the researcher deleted from the total population those students whose matriculation pattern was further out of time sequence or was otherwise nonstandard.

Further details about choices made in selecting students for inclusion in the test population are given in Chapter IV.

Summary

Three engineering mechanics courses comprised the instructional system. The system provided a modularized matriculation path individualized to each student's engineering subdiscipline. It also provided a nonmodularized path utilizing periodic examinations. The modularized versions of the three courses consisted of nine modules for most students. Unlimited no-penalty retaking of module proficiency tests was permitted. All students took the same end-of-course final examination. Several factors influenced selecting a relatively homogeneous test population to provide a data base for analysis.

CHAPTER IV

METHODOLOGY, ANALYSIS OF DATA, AND FINDINGS

Introduction

This chapter explains the investigative nature of the study, states the null hypotheses, discusses the data collection decisions, and presents graphical representations of selected data for visual observation. An initial chi square analysis and a revised analysis are then summarized and reasons are stated for discontinuing use of the chi square method of analysis. An alternative analysis using linear regression is then described and applied to 10 ESM 301, 302, and 303 sections, and the findings are stated. The chapter then presents adjunct findings related to self-pacing and to student attitude. A summary concludes the chapter.

Nature of Study

This was an associational study which sought to determine if a measurable association existed between the number of module test retakes and the final examination score. This was an *ex post facto* scientific inquiry examining educational variables in a real life setting. Systematic controls of actions taken were lacking since no control group was available for comparison. This study therefore sought to determine an association and did not imply that a cause and effect relationship necessarily existed. The "effect" or associational strength of a weak

variable was sought in the presence of many other variables that affect student achievement.

The analysis proceeded heuristically, seeking to identify extraneous variables and control their influence by the choices of data selection and the designs of statistical analysis.

This was an exploratory field study seeking to detect a possible association between the variables that would provide usable information to the faculty administering the innovative instructional system and that would lay the groundwork for those who may conduct a systematic test of the primary hypothesis in an experimental setting.

List of Hypotheses

Primary Null Hypothesis

The primary focus of this research related to the retaking of module completion tests as to whether the amount of retaking was associated with student achievement.

The primary null hypothesis was

> H_0: The number of times that students utilized the provision for unlimited no-penalty retaking of module proficiency tests during the ESM 301, 302, or 303 course was not related to student achievement as indicated by score on the end-of-course final examination when other reference or causal variables were controlled.

Stated simply, this null hypothesis was

> H_0: The extent of retaking of module completion tests was not related to student achievement.

Adjunct Null Hypotheses

Self-pacing and student attitude were two adjunct topics considered by this research. Analyses of these topics are presented briefly at the end of this chapter. The adjunct null hypotheses were

H_0: The completion date of student following the modularized version of ESM 301, 302 or 303 was not related to student achievement.

H_0: The attitude of students concerning the modularization of ESM 301, 302, and 303 was not related to student achievement.

Rationale for Using "Modified Junior Year GPA"

The dependent variable or criterion was student achievement, which was multi-determined. The effects of ability and environment had to be statistically controlled. High school GPA, high school rank, freshman GPA, cummulative GPA, SAT scores, and the Florida battery of 12th Grade test scores were examples of ability variables that could have been used to predict a student's performance. Class load, residence, car ownership, recreational and athletic participation, student associations, family status, and part-time employment were examples of environmental variables. Personality and work habit variables overlapped both of the above categories. A control was needed for the effect of these various ability and environmental variables. A specially calculated grade-point average was selected as a means of controlling for these variables.

Any grade-point average is to some extent a possible predictor of a given student's expected performance in some other academic situation.

Chapter II discusses this point. In general, research suggested that the more current the GPA selected, the better it would serve as a predictor. The plan of this research was, therefore, to use a specially calculated concurrent GPA. The researcher proposed that a concurrent GPA was a single measure reflecting the combined effort of the many ability and environmental determinants summarized early in this section. These variables affected a student's achievement in the modularized courses. These same variables affected that student's achievement in traditionally taught courses taken concurrently. These latter were taken as a reference that reflected the effects of the many external variables.

The researcher therefore established the term "modified junior year GPA." Three quarters were included in order to correspond to the three quarters in which a student took the three ESM junior level courses. Many individual students were retained in the data pool even though they began the series before their junior year, or completed the series after their junior year, or did not take all three courses. The researcher therefore had to select three representative quarters for each student. The selected quarters were those in which the three ESM courses were taken. For students not taking all three ESM courses, junior year quarters were selected to provide enough data for a representative average.

In order not to compare something to itself, the ESM courses were deleted from the record of the three selected quarters. The modularized course thermodynamics, ME 360 was also deleted. The remaining courses were therefore independent of the modularized courses being investigated but concurrent with them. These selected courses were taken in approx-

imately each student's junior year. The GPA of these courses was calculated for each student and the term "modified junior year grade-point average" was appropriate.

Analysis of the Uniformity of the Modules and Units

The several versions of the three courses of the modularized engineering mechanics instructional system were described in Chapter III. Each module had several end-of-module tests.

After several boxes of student learning laboratory folders were obtained, an analysis was made of the relative difficulty of the 34 modules. A tabulation was made of how many students failed a given module the first time those students attempted one of its tests. The results are shown in Appendix D. The number of tabulated initial module attempts varied because of course and version differences, dropouts, legibility of student assistant handwriting, and completeness of records.

The variation shown within the percentage column showed clearly that the difficulty of the modules was nonuniform. This variation in itself was not serious for purposes of this research because all comparisons were made for students taking the same sequence of modules. The total number of retakes was important, but where the retakes occurred was not.

Next an analysis was made of the relative difficulty of the end-of-module tests within each module. The number of different tests available for random selection varied from module to module. A tabulation was made of the number of times students failed each of these tests on the first attempt. The detailed results are shown in Appendix

E. The large variation of difficulty of the end-of-module tests within several of the modules constituted a problem for this research. Students followed randomly occurring unequal paths as they progressed through the sequence of modules. This condition was recognized and accepted as a cause of dispersion that could not be statistically controlled.

Data Collection and Selection

Despite the researcher's intent to include all students of many classes in the data base, the number of usable student histories decreased considerably with the several types of preliminary tabulating of the several components of the data. Many students were lost from the test population because they did not follow or did not complete the modular option. Students were also lost because they took the courses unusually early or unusually late rather than in their junior year, because they took an unusual version of a course, or because one of the components of the data was missing. A discussion of the selection process is given in Appendix F.

The resulting data pool consisted of selected students from 10 usable sections of ESM 301, 302, and 303. There were numbered 1 through 10 and are identified as shown in Table 3. A further processing of the data was made after the initial chi square analysis described later in this chapter. Descriptive statistics concerning the data are presented later in this chapter.

TABLE 3

ESM SECTIONS USABLE FOR ANALYSIS

Section	Designation	Date	Section Number
1	ESM 301	Fall '73	3743-V
2	ESM 301	Fall '73	3744-V
3	ESM 301	Winter '74	3548-V
4	ESM 301	Spring '74	3411-V
5	ESM 301	Fall '74	3762-V
6	ESM 301	Fall '74	3765-V
7	ESM 302	Summer '74	2136-V
8	ESM 302	Fall '74	3767-V
9	ESM 303	Spring '74	3414-V
10	ESM 303	Fall '74	3768-V

Characteristics of the Data

The data distribution was not bell-shaped. The final examination score distribution had an upper limit at 100 and was skewed. The modified junior year GPA distribution has an upper limit at 4.00 and was skewed. These deviations from the normal distribution were inherent in the test instruments.

The number of retakes of module tests was a noncontinuous distribution. This was necessarily so because this was a count function rather than a mearurement.

Graphical Presentation of Selected Data

Three types of raw data were collected as described in the previous section. These were a GPA, the final examination score, and the

number of retakes of module tests. For purposes of chi square analysis, the first two were combined into a measure of relative achievement. Prior to that processing, this section presents selected graphs showing the general nature of the selected data.

Graphs are presented in Appendix G for the data of Sections 1, 2, 3, and 9. Sections 1, 2, and 9 are the three sections having statistical significance in the multiple regression analysis described later in this chapter. Section 3 is typical of most of the other sections, which have high dispersion of data and for which no statistically significant conclusions could be found. These data were graphed to permit visual inspection of whatever patterns might be discernible in the selected data. These graphs did not control for the effects of aptitude and environment upon each student's final examination score. This is to say that none of the graphs showed relative achievement and hence none directly related to the primary null hypothesis of this investigation. The graphs show that considerable dispersion existed within the data but did not show any clustering worthy of special investigation.

Summary of an Initial Chi Square Analysis

Three sections of ESM 301 were randomly selected for an initial large scale evaluation of the method previously described as the initial plan for chi square analysis. Ninety-nine student histories were used to permit their being divided into three equal categories for the contingency table. The chi square statistic indicated no statistical significance. This lack of significance indicated that the number of retakes was indeed a subtle influence. If it existed, a

more precise method of analysis would be needed to reveal it.

Summary of a Revised Chi Square Analysis

Procedural changes were made before proceeding with a full scale data analysis using the chi square method. In the initial analysis the dividing line between students typically fell with a group of students all having the same number of retakes. Random numbers had been used to determine how that group of students would be divided. The use of equal size groups in the contingency table was discontinued to increase the sensitivity of the method of analysis.

A chi square contingency table must have an expected values of at least five in every cell. Otherwise the chi square statistic is not valid because of the threat of instability. The problem of having each individual cell expected frequency be equal to or greater than five had originally appeared to be small because of apparent wealth of large ESM sections available for analysis. The many deletions of students to provide homogeneity and reduce dispersions substantially reduced the data pool as was described previously.

The original data tabulation used only Version 10 of ESM 301, a nine module version. Version 11 was identical except that it did not include Module 7. Electrical engineering students took Version 11. They were a substantial group. The researcher retabulated all retake data, disregarding Module 7 information on the student record sheets. This adjustment made Version 10 become an eight module package identical with Version 11. The total number of usable students per ESM 301 section was therefore increased.

Several chi square analyses were then made for different combi-

nations of the revised data for the six ESM 301 sections. The nine cell contingency table was compressed into a six cell table by grouping the number of retakes into the two categories of few retakes and many retakes. This was to insure that the expected frequency of each cell would be at least five. Some of these data groupings produced an apparent statistical significance. Observation of the data points within the contingency table led the researcher to conclude that the data processing method probably introduced a bias that contributed to the apparent significance. The method of controlling for aptitude and environment was to subtract a student's expected score from his actual score after standardizing both types of data. The expected score was determined from the modified junior year grade-point average. This process appeared to overcompensate and introduce a bias. For example the researcher found that a high GPA student was almost precluded from being categorized as achieving better than expected.

Because of threats to validity that appeared to have been introduced in preparing the raw data for chi square analysis and because of the lack of sensitivity to minor distractions between observed data points, the researcher abandoned further use of contingency tables and chi square analysis.

Linear regression analysis was the method chosen for a re-analysis of the data.

Multiple Linear Regression Analysis for All Ten Sections

The variables associated in this investigation were (1) GPA, (2) number of retakes, and (3) score on the final examination. A high

GPA student would reasonably be expected to do well on the final examination. A student requiring few module retake tests would seemingly be having little difficulty and on this basis would be expected to do well on the final examination. Stated conversely, a student requiring many retakes would appear to be having difficulty in mastering the subject matter and would reasonably be expected to have a resulting low score on the final examination. These two expectations were combined into a single mathematical equation as follows:

$$\text{Score} = B_0 + B_1 \times \text{GPA} - B_2 \times \text{Retakes}$$

This typical linear probabilistic model was appropriate as a deterministic model for representing the best fit line through the scatter diagram of the observed data. The method of least squares was used to find this line of best fit to the empirical data. B_1 and B_2 were the regression coefficients.

The above model was applicable only to students who chose to follow the modular option to completion. Students who discontinued the modular path could have taken the intracourse examinations or they could have become dropouts. Students not completing the modular option were a sizable group. Research concerning them was conducted by Dr. Eisenberg and was described in his article which appears herein as Appendix A.

The data for each of the 10 ESM sections was transmitted to the Northeast Regional Data Center located at the University of Florida at Gainesville for processing by the IBM 370 Model 165 computer. A remote terminal at the University of North Florida in Jacksonville was used for data transmission. The procedures used were part of the Statistical Analysis System (SAS) designed by Anthony James Barr and James Howard Goodnight at the Department of Statistics at North Carolina State University, Raleigh.

A confidence level of 95% was set as the criterion for judging whether statistical significance existed. Stated in other terms, the critical value chosen was at the .05 (5%) level of significance.

The appropriate Statistical Analysis System procedure was used to determine the equation of the best fit line and analyze the dispersion of the data points about this line to provide a numerical measure of the statistical significance of the calculated B coefficients of the multiple regression equations. Analysis of variance was the statistical method used. Overall, if significance existed, at least one of the B_1 and B_2 coefficients was meaningful and further mention of these quantities was warranted.

A summary showing overall probability for the 10 sections is shown in Table 4, an overall analysis of variance summary.

The level of significance, which was the probability of chance occurrence, is shown at the right in the column labeled P for probability. This was the probability of the occurrence being greater than the F statistic calculated by analysis of variance. A probability of .05 or less was significant.

The probability column shows values much larger and much smaller than .05, the 5% value for adjudging significance. To seek an explanation the researcher prepared Table 5, summarizing pertinent information.

Table 5 shows the circumstances and the data that pertained to the 10 sections. The researcher looked for any clearcut explanation at the great variation of probability value for the 10 sections. Variation in difficulty of the final examination of each section was not an explanation. This uncontrolled random external variable caused the numerical

TABLE 4

ANALYSIS OF VARIANCE SUMMARY

Section	Source of Var.	DF	Sum of Squares	Mean Square	F Value	P
1	Regression	2	4760.4	2380.2	11.6	0.0003
	Error	33	6725.8	203.8		
	Corrected Total	35	11486.3			
2	Regression	2	4272.8	2136.4	12.8	0.0002
	Error	34	5657.3	166.3		
	Corrected Total	36	9930.2			
3	Regression	2	511.2	255.6	1.2	0.3195
	Error	22	4672.7	212.3		
	Corrected Total	24	5184.0			
4	Regression	2	402.0	201.0	4.1	0.0239
	Error	35	1703.1	48.6		
	Corrected Total	37	2105.2			
5	Regression	2	310.8	155.4	1.1	0.3227
	Error	46	6161.1	133.9		
	Corrected Total	48	6472.0			
6	Regression	2	962.5	481.2	2.1	0.1371
	Error	21	4649.2	221.3		
	Corrected Total	23	5611.8			

TABLE 4 - continued

Section	Source of Var.	DF	Sum of Squares	Mean Square	F Value	P
7	Regression	2	2996.5	1498.2	9.6	0.0139
	Error	6	930.3	155.0		
	Corrected Total	8	3926.8			
8	Regression	2	371.9	185.9	1.3	0.2642
	Error	27	3598.1	133.2		
	Corrected Total	29	3970.1			
9	Regression	2	1966.5	983.2	23.9	0.0001
	Error	14	573.9	40.9		
	Corrected Total	16	2540.4			
10	Regression	2	2777.7	1388.8	6.4	0.0058
	Error	24	5141.1	214.2		
	Corrected Total	26	7918.9			

Source of Var. = Source of variation within the data
DF = Degrees of Freedom
P = Probability of chance occurrence. P = .05 or less indicates significance

TABLE 5

CONCOMITANT DATA FOR THE ANALYSIS OF VARIANCE SUMMARY

Section Number	ESM Designation	Quarter	N	GPA		Score		Retakes		P
				μ	σ	μ	σ	μ	σ	
1	301	Fall '73	36	2.96	.68	62.9	18.1	3.58	3.13	.0003*
2	301	Fall '73	27	3.09	.59	68.2	16.6	3.62	3.32	.0002*
3	301	Winter '74	25	3.27	.54	69.2	14.7	4.20	3.62	.3195
4	301	Spring '74	38	2.94	.53	86.6	7.54	3.58	2.60	.0239*
5	301	Fall '74	49	3.22	.57	68.6	11.6	2.35	1.94	.3227
6	301	Fall '74	24	3.17	.62	66.1	15.6	3.08	2.02	.1371
7	302	Summer '74	9	3.30	.48	43.1	22.2	2.89	2.03	.0139*
8	302	Fall '74	30	3.06	.52	52.8	11.7	4.47	2.71	.2642
9	303	Spring '74	17	3.14	.58	56.8	12.6	2.35	2.12	.0001*
10	303	Fall '74	27	3.00	.63	48.0	17.4	1.70	1.66	.0058*

N = Number of students in selected data
P = Probability from analysis of variance summary
* = Significance

value of the regression coefficients to vary from section to section but did not effect their reliability. Three of the 10 sections were taught by Dr. Eisenberg, the designer of the modularized instructional system. These were Sections 1, 9, and 10. An interesting observation is that all three of these sections showed significance. This suggested that closer control of these sections may have existed with the result that the influences of external variables was reduced. On the other hand, sections taught by the other two professors involved showed cases of both high and low value for the same professor. This suggests that some external variable other than the professor introduced dispersion into the data. Correlation between two independent variables increases the likelihood that a more basic determinant can affect both variables. Erratic results from separate investigations can result from this cause. (That correlation existed was obvious from the graphs of Appendix G. Quantatively the correlation coefficients between GPA and Retakes for the 10 sections were as follows: (1) -.32; (2) -.50; (3) -.27; (4) -.09; (5) -.34; (6) -.39; (7) -.08; (8) +.04; (9) -.29; (10) -.36.)

These sections having significance were selected for further examination. Section 10 was included as essentially being significant with its 5.8% value of probability. Six sections were thus selected. Table 6 shows the regression coefficients and their associated P values for these six sections. In all six cases it was found that GPA was a significant predictor of the final examination score. The number of retakes was not always significant at the 95% level. Table 6 was therefore arranged into the two sections shown.

As shown in Table 6B, both GPA and Retakes were significant predictors of final examination scores in Sections 1, 2, and 9. Unexpect-

TABLE 6

MULTIPLE REGRESSION ANALYSIS RESULTS FOR SECTIONS SHOWING OVERALL STATISTICAL SIGNIFICANCE

A. Summary data for sections in which only GPA was individually significant

Section	Source of Var.	Regression Coef.	P
4	Intercept	68.806	.0001
	Retakes	-0.110	.8050
	GPA	6.178	.0076
7	Intercept	-57.763	.1195
	Retakes	-4.360	.0923
	GPA	34.420	.0061
10	Intercept	6.415	.6969
	Retakes	-1.438	.4448
	GPA	14.684	.0061

B. Data for sections in which GPA and Retakes were both individually significant

Section	Sourve of Var.	Regression Coef.	Prob.	Partial SS
1	Intercept	30.438	.021	
	Retakes	-1.679	.047	866.38
	GPA	13.000	.001	2464.59
Regression equation is Score = 30.438+13.000(GPA)-1.679(Retakes)				
2	Intercept	38.495	.013	
	Retakes	-1.722	.028	882.282
	GPA	11.640	.009	1267.109
Regression equation is Score = 38.495+11.640(GPA-1.722(Retakes)				
9	Intercept	-10.339	.313	
	Retakes	1.963	.026	254.251
	GPA	19.910	.0001	1954.818
Regression equation is Score = -10.339+19.910(GPA)+1.963(Retakes)				

A probability of .05 or less is significant

Partial SS = Partial sum of squares and indicates the amount of variation attributed to one independent variable when the effect of the other is controlled.

edly for Section 9 the retake coefficient was positive. This positive coefficient indicated that students who had trouble in passing module tests made higher than expected final examination scores. This finding implied that students retaking the tests accomplished much learning and surpassed the students initially appearing to be superior.

The Section 9 data were plotted to permit further investigation of this unexpected result and are shown in Figure 10 of Appendix G. Inspection showed one apparent wild point representing the moderately high raw score grade of 62 for a student having the markedly high number of seven retakes. This one point in a leveraged position for a small population appeared to be sufficient to cause the upward slope of the data pattern and the corresponding positive value of the regression coefficient. Removal of this one point would seemingly leave a data pattern having a downward slope with increasing values of the retake variable.

The wild point (Retake = 7, Score = 62) was removed from the data base and the Section 9 data were reprocessed. The Retakes regression coefficient (with GPA controlled) not only remained positive but decreased only a trivial amount from 1.962 to 1.955. This indicated that when GPA was controlled, the apparent wild point was "right on." The point was very consistent with the regression equation when calculated from the main body of data. The seemingly obvious explanation had failed to explain the unexpected results for Section 9.

The researcher's next attempt to discredit or support the unexpected findings for Section 9 involved use of additional calculations provided by the SAS regression analysis.

Table 6B also shows the partial sum of squares, which was variation

attributable to one independent variable when the effect of the other had been removed. Table 6B therefore indicates the relative effect of the two independent variables. Specifically it shows how the concurrent GPA predominated over Retakes in predicting final examination scores. The preceeding does not refer to the size of the regression coefficients, which were measured by different scales.

The appropriate SAS procedure was also used to perform regression analysis for predicting scores from GPA alone and from the number of retakes alone. These two analyses were performed for each of the 10 sections. Table 7 shows the probability that these regression analysis outcomes could have occurred by chance.

TABLE 7

ANALYSIS OF VARIANCE RESULTS FOR REGRESSION ANALYSIS PERFORMED FOR GPA ALONE AND RETAKES ALONE

Section No.	Probability for Chance Occurrence	
	Retakes	GPA
1	.0063*	.0002*
2	.0004*	.0001*
3	.4185	.1442
4	.6521	.0063*
5	.1487	.2911
6	.1328	.0753
7	.2110	.0136*
8	.8673	.1006
9	.7954	.0001*
10	.0973	.0016*

*Significant

Table 7 shows that except for Section 5 the probability for GPA was much smaller than that for retakes. These smaller values for GPA indicated that concurrent GPA was a more reliable predictor than was the

the number of retakes. This statement does not refer to the numerical size of either regression coefficient. The size of the trend (the slope of the regression line) was meaningless if there was little confidence in its existence because it likely occurred by chance. The probability figure related to this confidence. The smaller the probability figure, the less likely that the regression line, whether steep or shallow, occurred by chance. It is worthy of note that only the six sections showing significance of GPA used alone showed significance for GPA and retakes used together.

The proceeding has shown that outcomes having statistical significance were found, that other outcomes were far from significant, that correlation between the independent variables and varying environmental conditions provides a possible explanation as to why these large differences might have occurred among the sections, and that concurrent GPA was a more reliable estimator (is more closely associated with) final examination scores than was the number of retakes. For Sections 1 and 2 the final examination score appeared to decrease with increasing retakes. For Section 9, the opposite appeared to be true.

At this point it could have reasonably been argued that the "effect" of Retakes, if any, was so small that it was usually lost in the residuals (the clutter remaining after the effect of GPA was removed) and that occasional indications of significance which showed conflicting results were random occurrences within the clutter. This reasonsing would support a conclusion that any "effect" of the number of retakes was too small to be detected by the methods of this investigation and that the primary null hypothesis that no association existed could not be rejected.

The researcher's final attempt to discredit or support the unexpected finding for Section 9 involved still another effort to identify an external causal variable. The researcher again reviewed the learning laboratory folders and discovered a satisfactory explanation for the contrasting findings of Sections 1 and 2 as compared to Section 9.

Sections 1 and 2 involved beginning engineering students who were within the instructional system in Fall 1973. Section 9 involved students approximately beginning their senior year and who were within the instructional system in Spring 1974. More mature students were involved, and some of the instructional system procedures had changed. Unlimited retaking of module tests was still permitted but delays between tests were encouraged by procedural changes that had been introduced. The results was clearcut. The researcher found that for Sections 1 and 2 students typically took two, three or even four tests of a module on the same day. The particular unit finally passed was often one of those shown by Appendix E to be unduly easy. The students had manifestly abused the system and eventually passed a module without properly learning the subject matter. On the other hand the researcher found that students in Section 9 predominantly had at least one day between each retake.

The dissimilarity of the two situation was pronounced. A reasonable explanation for the statistical results had been found and the finding for Section 1, 2, and 9 can be supported rather than be attributed to random occurrences within the clutter that remained after the predominant effect of GPA had been removed.

Effect of Date of Completion of the Modular Path

As an adjunct study, the "effect" of the rate at which students progressed through the modularized version was sought. As an overall indicator of whether a student raced through to completion or whether he procrastinated, the researcher extracted from the student record sheet the date of completing the final module. Two sections were randomly selected. The date of the month was used as the numerical measurement. This constituted a third independent variable in addition to GPA and Retakes and was called Date. Table 8 shows the results of a multiple linear regression analysis. The high value of P associated with Date indicated high likelihood that the regression coefficient for date of completion occurred by chance. This limited investigation therefore did not indicate that date of completion had a reliable association with final examination scores.

TABLE 8

MULTIPLE LINEAR REGRESSION ANALYSIS
WITH DATE OF COMPLETION OF MODULES INCLUDED

Section	Overall P	Date P
1	.0003*	.7391
7	.0767	.3745

p = Probability of chance occurrence
* = Significant

Student Attitude

As a second adjunct study, the association between student attitude and final examination score was sought. Student attitude referred to

the feeling of students toward the modularizing of the engineering mechanics courses and their taking of the courses in this form.

The researcher sought an attitudinal measuring instrument that could be used at the time of the final examination. A quick response instrument was needed in order to obtain the cooperation of professors and students. Originally planned to suffice only to divide students into broad categories for chi square analysis, a multiple choice questionnaire was prepared.

To validate this instrument, a trial run was conducted using a group of electrical engineering students who had already experienced the ESM modularized sequence. Many students checked the most favorable of the three choices offered for several of the questions. An inadequate spread of results occurred. The researcher then prepared the revised questionnaire of Appendix H, which had two choices of favorable response such as "strongly prefer" and "prefer." This questionnaire was presented to students in December 1974 during their final examination period. The three sections of Fall ESM sections were involved. They were Sections 5, 6, and 10. Table 9 shows the result of a multiple linear regression analysis with attitude used as a third independent variable in addition to GPA and Retakes. The high value of P associated with attitude indicated that the regression coefficient for attitude occurred by chance. This limited investigation did not indicate that student attitude concerning the modularized ESM courses was reliably associated with final examination scores.

TABLE 9

MULTIPLE LINEAR REGRESSION ANALYSIS
WITH ATTITUDE INCLUDED

Section	Overall P	Attitude P
5	.1025	.1948
6	.2606	.5999
10	.0594*	.8398

P = Probability
* = Significant (borderline case)

Summary

This investigation was an associational study seeking to relate student utilization of no-penalty retaking of module tests with final examination scores when other variables were controlled. This *ex post facto* investigation proceeded heuristically, seeking paths of inquiry that offered promise.

Careful selection of data was used as a major statistical control. Much effort was devoted to establishing a large data base in which elements had been screened for uniformity of situation so as to reduce dispersion. Ten sections of engineering mechanics classes were usable. Much effort was devoted to establishing broad categories for chi square analysis. Modifications to the initial procedures were necessary. Much data processing was performed to produce a numerical measure of a student's achievement relative to his expected achievement. A modified junior year grade-point average was used as a reference for establishing this relative achievement. The lack of a validated weighting factor for applying this reference was the final reason found for questioning the use of chi square analysis for the data of this investigation. A

finding of significance was disregarded because of threats to its validity.

The investigation then proceeded by changing to regression analysis. Final examination score was the dependent variable to be predicted by concurrent grade-point average and number of retakes as two independent variables. Significance occurred in several cases. GPA was more associated with final examination score than was the number of retakes. Regression equations were stated for the three sections found to have significance for both GPA and Retakes. An observation of much apparent relevance was that students taking more than one proficiency test of a module on the same day showed a decreasing final examination score with increasing total number of retakes but that students not retaking on the same day of an intiial failure showed an increasing final examination score with increasing total number of retakes. Adjunct studies concerned whether final examination score was associated with the date of student completion of the modules or with student attitude about the modularized courses. Unsophisticated measuring instruments were used. No significant association with final examination score was found for either adjunct variable.

CHAPTER V

SUMMARY

Introduction

This chapter presents a summary of the preceding four chapters. The topics have been rearranged and combined. Details of unproductive methods of inquiry have been minimized.

The Instructional System

Three introductory junior level courses of engineering mechanics at the University of Florida were offered in an innovative modularized format. The courses were Statics (ESM 301), Dynamics (ESM 302), and Mechanics of Materials (ESM 303). Various options were available. One feature was the taking of end-of-module proficiency tests selected at random with provision for retesting of students until a grade of A or B was obtained. Initial failure carried no weight in determining a student's letter grade for the course. This feature was called the unlimited no-penalty retaking of module tests.

Students could initially or later choose the option of taking two scheduled intracourse examinations in lieu of completing the module tests. All students took the same final examination.

Individualization of the modular path was provided for students of the several engineering specialties. This was accomplished by having somewhat different versions of the three courses. The

prearranged versions consisted of slightly different grouping of the total of 34 modules of the three course sequence. The different versions did not always have the same number of modules.

Student assistants provided tutoring in a learning laboratory and administered the module proficiency testing feature of the instructional system.

Professors conducted regularly scheduled lectures for those students wishing to attend.

All students participated in this instructional system although they did not have to follow the modularized path. There were no separate traditional taught sections that could serve as control groups for investigative comparisons.

Need for the Study

All students do not learn best in a given type of learning environment. A trend in American education has been to provide less rigid course structuring. When an innovative system with options is introduced, a relevant question concerns how well the student population masters the subject matter. This question concerns group attainment. A control group would be needed to answer this question. Separate questions could be asked concerning how various ability or personality types achieve. Subgroup comparisons could be used to answer this question. When the modularized instructional system of this investigation was implemented in the real life circumstances of an engineering college, there was neither control groups nor knowledge of personality parameters of individual students.

A remaining question concerned how student use of the unlimited

no-penalty retaking of module proficienty tests was related to student performance on the final examination. The extent of retaking and also the rate of progress along the modular path were observable characteristics. They could be of assistance to the faculty provided that reliable meanings could be associated with these two characteristics. A major question was whether student reliance upon the unlimited retaking feature was associated with student achievement as measured by the score on the final examination. (A meaningful answer required that the effect of individual student ability and unique environmental situation be eliminated.) Another question was whether a student's rate of progress was associated with his achievement. Still another question was whether an individual student's attitude toward the non-traditional instructional system was associated with his achievement.

Nature of the Study

Concerning the above questions, this investigation predominately treated the one concerning the retaking of module tests. The primary null hypothesis stated that the extent of student use of the unlimited no-penalty retaking of module tests was not associated with student score on the final examination.

This was an *ex post facto* field study. It examined the recorded records of a functioning college of engineering in which experimental controls designed to facilitate this investigation were lacking. Appropriate selection of the data that was included was the method used to establish a somewhat uniform test population in which the effect of extraneous variables was reduced.

This was an associational study. Because no randomly assigned

control group was available, this investigation sought associations rather than causal relationships between the variables.

Student performance on the final examination of a course is multi-determined. To provide a meaningful finding about the retaking variable alone, the strong effects of individual student ability and unique environment needed to be eliminated. The methods of data reduction and statistical analyses were used to accomplish this. One of the techniques used was to calculate a grade-point average of selected courses taken at the same period of time that a student participated in the modularized sequence of engineering mechanics courses. It was assumed that the many aspects of ability and environment were compared to this GPA. The raw score on the final examination was compared to this GPA in a way appropriate to provide a measure of relative achievement, achievement relative to the expected or par performance of a student. With other variables thus partially controlled, the existence of an association between performance and extent of retaking of module tests was then sought.

Review of the Literature

Modularized courses at the college level and provisions for no-penalty retaking of tests are seldom reported subjects. A computer search of ERIC and of dissertation abstracts found few articles. Manual searching was therefore used.

Examples of the extensive research in the use of grade-point averages to predict academic performance were reported. These examples related to the use in this investigation of a GPA to estimate the expected performance of individual students, which was then compared

to observed performance. The literature indicates that GPA was often found to be one of the best predictors. A recent GPA seemed to be better than an older one.

Research finding concerning self-pacing and comparison of teaching methods were included in the review. The gist of these articles revealed that student ability was the primary determinant of student performance. The teaching method used was less important.

Uniformity of Difficulty of the Module Tests

Analysis of student records showed that some modules were harder to pass than others. This condition did not necessarily mean that individual students followed unequal paths. More serious for the purposes of this investigation was the finding that in some modules the difficulty of different proficiency tests varied. The random selection of unequal tests therefore created unequal paths for the students to follow. This caused a dispersion within the observed data for which there was no statistical control.

Data Collection and Selection

Data was collected from three sources. The special grade-point average was calculated from the Registrar's records. The number of retakes was determined from student folders from the learning laboratory. The final examination score was determined from the professors. The data base used for statistical analysis consisted of carefully selected histories of students taking and completing the same modular path. The options and individualization that had existed caused the records of many students to be unusable. Omissions of any part of the data caused additional records to be unusable. The final data

base consisted of selected data from 10 sections that were taught during approximately a two-year period.

Results of Chi Square Analysis

The independent variable for the chi square analysis was the number of times students retook module tests. This was count data and was used to establish categories representing the extent of student utilization of the retake provision.

The dependent variable was the final examination score and was a continuous variable. It was used to establish categories of achievement. This measure of a student's achievement controlled for ability and environment was the difference between his standardized final examination score and his standardized modified junior year GPA. These standardized numbers were standard deviations measured from the mean translated to zero. Subtracting these quantities produced a number assumed to be indicative of how well a student did on his final examination as compared to his expected achievement. These differences were placed in rank order and were then divided into suitable categories.

A contingency table and chi square test was used to compare the observed and expected frequencies. The chi square analysis tests for statistical significance of the divergence of observed data from expected data.

The grouping of the data of this investigation into categories required the arbitrarily establishing of boundaries within the data distribution. Several groupings were tested.

An analysis of the data of the six ESM 301 sections showed greater dissimilarities than had been expected. The groupings of data to pro-

duce sufficiently large numbers was found to be less feasible than anticipated.

One grouping involving compatible data from two sections produced significance. Scrutiny of the steps of the data processing and of the certain cell frequencies of the resulting contingency table suggested that a threat to validity existed. The method of relating concurrent GPA to raw score on the final examination to produce a quantitative measure of a student's performance relative to his expected performance appeared to overcorrect for GPA.

The several problems that had arisen in processing the raw data into a form for use in the contingency table cast doubt on the validity of whatever significance the chi square statistic might show. The method of analysis using the chi square statistic was abandoned.

Results of Linear Regression Analysis

Ten ESM sections yielded usable data. This data was subjected to linear regression analysis. The 95% confidence level was established as the criterion for adjudging that statistical significance existed.

The dependent variable was raw score on the final examination.

The modified junior year grade-point average represented a concurrent GPA in other courses taken at the same time that the ESM courses were taken. The concurrent GPA was the GPA used for all analyses. It was considered to represent the effects of both ability and environment. The number of retakes referred to how many times a student attempted to pass a module proficiency test after failing an initial attempt. Retakes was the other independent variable of interest.

Used alone as the single independent variable, GPA predicted final

examination score at a statistically significant level in six of the 10 sections. Used alone, retakes significantly predicted (was associated with) score only a single time. Thus it was shown that grade-point average was more reliable than retakes in predicting score.

The null hypothesis considered the effect of retakes when the effect of GPA was controlled. A multiple regression analysis for the 10 sections was therefore performed using both GPA and retakes as independent variables predicting score.

Overall significance was obtained for the same six sections for which GPA alone produced significance. Including retakes on a second variable to account for part of the observed variation did not increase the number of sections showing overall significance. This is a further indication that grade-point average is the dominant variable of the two.

The regression coefficients for GPA and score were calculated, but the retake coefficient was not statistically significant for three of the six sections showing overall significance. GPA alone had accounted for enough of the variation to cause overall significance. Thus, only three sections were found to have full statistical significance. Conclusions were then drawn for the analysis results of these three sections.

For these three sections, the portion of the variation attributed to GPA was much greater than that attributed to retakes. This is a specific indication that GPA is the more powerful variable in predicting the score on the final examination.

The existence of statistically significant nonzero regression coefficients was the issue of vital interest to the hypothesis of this investigation. The numerical values of these coefficients are

functions of the three scales used to measure the three variables (e.g. Score was measured from 0 to 100) and are deliberately not repeated in this summary. The details appear in Table 6 of Chapter IV.

The important finding concerns the nature of the regression coefficient for the retake variable in the three sections where it had been isolated from the random clutter (had been found to have statistical significance).

Two of the sections were ESM 301. The regression coefficient for retake was negative indicating that an increasing number of retakes was associated with a decreasing score on the final examination. The remaining section was a small ESM 303 section. A positive coefficient was found indicating that an increasing number of retakes was associated with an increasing score on the final examination. It was not possible to attribute this unexpected finding to the effect of a "wild point" in the data or to any other cause that would discredit the finding.

Students of the two ESM 301 sections showed a strong tendency to retake tests repeatedly on the same day that an initial attempt showed that mastery of the subject matter had not been obtained. This was not so for the ESM 303 section. This was the major environmental condition found that offers an explanation for the different characteristics of the regression coefficients for the retake variable.

Instances of statistical significance were found for an association between the number of retakes and the score on the final examination. The lack of uniformity of the findings suggest that only qualified conclusions should be drawn, although an explanation for the lack of uniformity appeared to have been found. A more consistent

finding was that concurrent GPA is much more associated with final examination score than is the extent of retaking of module tests.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the researcher's conclusions, recommendations for the faculty administering the instructional system studied, and recommendations for further research.

Conclusions

The innovative instructional system investigated by this exploratory field study was designed to provide options and alternatives to the students. It was not designed for research purposes. Many causes of dispersion could be only partially controlled.

A modified junior year grade-point average was calculated for traditionally taught courses taken concurrently with courses of the modularized instructional system. This concurrent GPA was felt to be a composite representation of individual student innate ability, personality factors, and whatever external environmental conditions that might have influenced individual students. Use of this concurrent GPA as a predictor of student achievement was believed to control for many of these basic influences.

The variation of difficulty from module to module was not felt to cause a problem to this research. The variation of difficulty of proficiency tests within some of the modules may have been a cause of

dispersion that could not be statistically controlled. This variation is believed to have been a contributing cause of the negative regression coefficient found for Sections 1 and 2 (ESM 301) for the retakes variable. An easy test within a module allowed a student taking repeat tests to have greater chance of receiving an easy test and demonstrating an apparent proficiency that did not in fact exist.

The immediate retaking of a module test after an initial failure did not occur in Section 9 (ESM 303). A further fact pertained. The subject matter of ESM 301 was relatively easy. Students requiring many retakes were likely to have been marginal students. Repeating may not have produced genuine comprehension. The subject matter of ESM 303 was difficult. The more mature students taking this course may have profited from restudying and retaking the module tests. Taking additional tests with restudying would constitute a greater effort on the part of a student and probably provided increased learning. The researcher believes that this was the cause contributing to the positive regression coefficient for Section 9.

In summary, the extent of retaking of module tests was shown in some statistically significant cases to have an association with student scores on the final examination. This association was less reliably shown and was of lesser magnitude than that of concurrent GPA. The nature of this association rather clearly appeared to depend upon the conditions. An immediate retaking of a proficiency test after an initial failure probably did little to enhance comprehension and was likely to lead to an erroneous appearance of mastery. Restudying prior to retesting probably caused increased learning and comprehension.

The researcher concludes that while aptitude and environmental

factors were major determinants of academic achievement, the extent of retaking of end-of-module tests in the modularized courses was a second order effect that was occasionally detected by the investigation. The researcher interprets the findings to conclude that there was an association between the extent of retaking of modules tests and final examination score. The researcher concludes that the extent of retaking *per se* was not the entity that matters. The conditions under which the retaking occurred influenced the outcome.

The researcher does not feel that the negative regression coefficient for Sections 1 and 2 conflicts with mastery learning theory.

Because of the several special features of the instructional system investigated, the researcher suggests caution in generalizing all observations and findings to other instructional systems. The conclusion that the manner of retaking rather than the amount of retaking is the entity that matters is felt to be a worthwhile conclusion of general applicability.

Recommendations

The researcher recommends that the end-of-module proficiency tests be periodically monitored for uniformity of difficulty. This recommendation is especially applicable if individual tests are replaced from time to time to guard against the possibility of compromise of the testing system. Concerning cheating, the researcher in reviewing comments written in a space provided on the attitudinal questionnaire did not find indications that the existence of cheating was a major concern of the students.

There appears to be a discernible association between the extent

of module test retaking and the score on the course final examination. The conclusion that the effect of retaking depends upon the conditions is offered as a hypothesis to be investigated under controlled condition.

APPENDIX A

EXCERPTS FROM "A MODULAR INSTRUCTIONAL SYSTEM FOR INTRODUCTORY COURSES IN ENGINEERING MECHANICS"

APPENDIX A

EXCERPTS FROM

A MODULAR INSTRUCTIONAL SYSTEM FOR INTRODUCTORY COURSES IN ENGINEERING MECHANICS*

In designing an instructional system for the introductory courses in engineering, one must contend with a number of problems associated with the heterogeneity of the backgrounds, interests and abilities of the students served. Typically, a single department is assigned the responsibility of teaching a course which must meet the curricular demands of perhaps a dozen distinct degree programs. In large state universities it is not uncommon to find that students have completed their prerequisite studies at many different community colleges as well as at the university in which the course is offered. Consequently, the input competency of the students is highly variable. "Open door" and "affirmative action" policies tend to contribute to this variability.

If the introductory courses are to be anything more than a passive sorting or classification system, then special attention must be given to the problems they present. The introductory mechanics courses in statics, dynamics and mechanics of materials are archetypical of ser-

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vice courses which must meet the demands mentioned above.

At the University of Florida, an instructional system employing a highly flexible combination of modular curriculum packaging, variable pacing, programmed learning materials, computer managed instruction and conventional lecture and examination methodologies has evolved. In an earlier paper exploratory studies, the basic design philosophy, and an outline of the system planned for the 1973-74 academic year were described. In this paper the system as implemented and its evolution in response to operational experience and increasingly severe budgetary constraints are described. The effect of alternate staffing strategies (graduate vs. undergraduate teaching assistants) upon cost and effectiveness is analyzed, as is the overall cost of operation in comparison with conventional systems. The results of preliminary studies on the effectiveness of the prescribed learning materials and activities are also presented.

The Basic System

The system of instruction consists of a sequence of courses in the subjects of Statics (ESM 301), Dynamics (ESM 302) and Mechanics of Materials (ESM 303) which are completed during the junior year by most students in the College of Engineering.

In the design of the system the following criteria were adopted:

Course Criteria

1) The system must accomodate variable student and departmental content objectives.

2) Variable input competencies must be recognized and accommodated.

3) Continuity of program effectiveness should be assured.

4) Variable faculty teaching styles must be respected.

5) Provision for continuous improvement and modification must be possible.

6) Instructional costs must be kept at economical levels.

7) Sanctions sufficient to ensure reasonable student progress should be imposed.

8) Objective measures of student performance and program effectiveness should be provided.

9) A variety of learning modes should be available to suit the student and subject matter.

In response to the first criterion it became apparent that the subject matter of these disciplines would have to be broken down into modules, and a prerequisite hierarchy established. Figure 1 illustrates a decomposition of the subject into the 34 modules upon which the system is based. The prerequisite hierarchy is indicated by the arrows. For example, the study of unit 16 on Plane Motion Dynamics requires direct prerequisites of units, 4, 5, 8, 12 and 15, which in turn imply the prerequisite study of units 1, 2, 3, 6, 10, 11 and 14. Thia à la carte menu was presented to the curriculum committees of each of the client departments, and a course of study tailored to the needs of their students was negotiated.

Table 1 shows the content of courses required for each of the undergraduage degree programs. As far as the University registrar is concerned there are only three <u>variable credit</u> courses in which the student may enroll. Within each of the courses, however, students may be enrolled in one of three to five different subcourses whose existence is of no concern to the registrar. A careful study of the content

of subcourses 30, 31, 32, 33 and 34 of ESM 303 will reveal their striking similarity. Subcourse 33 taken by aerospace engineering students differs from the standard course (subcourse 30) only in the addition of shear center and column buckling units to the curriculum. The nuclear engineers study the stress and deformations in thick-walled cylinders under thermal and pressure loading, while electrical engineers, for good but arcane reasons of a local nature, study units normally part of other courses, e.g., the static analysis of beams and damped vibrations of particles and rigid bodies.

The differences among most of the courses are small, but it is these small differences that lead to major debates in college curriculum committees, proliferation of courses in "Mechanics for XYZ Engineering" and/or dissatisfied clients of service courses. By employing the modular design it is possible to tailor the course to meet the different requirements of the clients and thereby provide better service.

The modular structure has the additional advantage of allowing one to tailor a course of instruction to meet special requirements. For example, a student who has completed a sophomore-junior level physics course in mechanics probably has a good background in particle dynamics, no experience in the static analysis of simple structural elements, and a weak background in rigid body dynamics. In such a case one may create an ad hoc course, administrable under the aegis of the standard dynamics course, which will allow the student to complete his study of statics and dynamics without leaving major gaps and without undue repetition.

Each of the courses employs a standard textbook, and a full set of lectures is scheduled. The schedule of lectures is distributed

to the students at the beginning of the term so that they may use the lecture as one of a number of learning resources. Our experience shows that most students benefit from the lectures of most professors. In any event, criterion no. 4 mandates the availability of a stage from which the faculty member responsible for the course may deliver his personal statement on the subject matter of the course.

In addition to the classical textbook a set of programmed study guides has been developed for the course sequence. The study guides are an adjunct and guide to the use of the standard texts. They are designed to give the student sufficient guidance to permit him to study the material independently. For each unit or module there corresponds a learning activity package as part of the study guide. Each of the modules contains:

1) A description of content and rationale for study of the indicated material.

2) A statement of prerequisites.

3) A list of behavioral objectives which the student is encouraged to use as a check list of tasks to be accomplished and abilities to be developed.

4) Commentary and guide to the text. This, the heart of the study guide, is written in a colloquial style but is carefully structured to require active participation of and frequent feedback to the student. The student is assigned tasks to read specific sections of the text, to provide missing steps in derivations, to identify implicit assumptions, to solve specific problems, to perform simple experiments, and to swear oaths of allegiance to the use of free body diagrams. In addition, the study guide provides remedial and advanced material. In this manner the student is asked to abandon his customarily passive role as reader. The technique is similar to that of standard programmed texts, but the programming steps

are considerably larger than is usual. This "macroprogramming" approach has the advantage of being considerable less time-consuming to prepare than traditionally programmed material. It also places greater responsibility upon the student and hopefully, by example, encourages the student to read technical material from a critical perspective.

5) Sample proficiency test. After the student has worked through the unit and reread the list of objectives, he is instructed to respond to a quiz printed at the end of the unit. Upon completing the quiz under the indicated conditions (duration, open book, closed book), he is instructed to read the solution provided in the package and to grade his own paper. The actual quiz in which he will be asked to demonstrate competency will be of a similar level of difficulty and offered under similar conditions.

The study guides were prepared and the modular course system implemented in stages during the academic year 1973-74. The statics, dynamics and mechanics of materials guides were put into use in the fall, winter and spring quarters, respectively. Since spring 1974, modular courses have been offered to approximately 300 students each quarter.

To provide additional assistance to the student, a learning laboratory has been established and staffed with graduate and undergraduate teaching assistants whose duties include tutorial services. The laboratory has typically been staffed about 40 to 50 hours a week and is heavily utilized by students.

All of the above features of the instructional system have been in effect since the fall of 1973 and are expected to be maintained in the foreseeable future. In other respects the system is undergoing a continuing evolution.

Modularity, Programming and Self-pacing

Modular instructional systems, programmed instructional systems and self-paced instructional systems are not synonymous.

A modular system is one in which the complete system is substructured into discrete components with specified functions and specified interreactions with other components. It is designed to meet specialized system criteria by selectively drawing upon a modular subset of the total system. Modular instructional systems are individualized systems in that they facilitate the construction of course syllabi to meet individual needs.

Programmed instructional systems are characterized by: 1) the explicit identification of changes (behavioral objectives) in demonstrable competencies and/or attitudes expected of the user of the system; and 2) by the adherence to psychological principles of behavior modification through reinforcement (positive feedback), pioneered by B. F. Skinner. These principles have been used to teach people to assemble M-1 rifles (psychomotor programming), to solve differential equations (cognitive programming), and to develop value structures (affective programming). Programmed instructional systems are individualized systems in that they are addressed to individuals rather than a public. They demand individual participation. They are based upon dialogues rather than soliloquies.

Self-paced instructional systems are designed to cater to variable student input competencies (criterion no. 2) and levels of effort. They permit the system designer to demand minimum performance levels of all students by permitting a variable time to meet these criteria. The Keller or PSI methods are typical of such systems. Because self-

paced systems are inherently subject to abuse by procrastination (criterion no. 7), they are rarely implemented in pure form. Most so-called self-paced systems are actually flexibly-paced systems. Self-paced systems are individualized systems of instruction in that they try to accommodate individual differences in ability and are subject to a significant extent to individual control.

Thus, modular, programmed and self-paced systems are, in different senses, individualized systems. Any given individualized system may assume to varying degrees the characteristics of all or some of these system types. The instructional system for engineering mechanics in use at the University of Florida since 1973 has been a consistently modular and programmed system with variable elements of flexible pacing.

As originally implemented, the system employed a significant element of flexible pacing strategy. Major traditional examinations were scheduled during the fourth and eighth weeks of a ten week quarter. Students had the option, however, of demonstrating proficiency (A-B performance) on module quizzes which could be taken on demand and repeated (different quizzes) as necessary without penalty. If a student demonstrated reasonable progress by the dates of the scheduled major exams, he was excused from the examinations. All students were required to take a comprehensive, traditional final examination. For students who completed nearly all the quizzes the final grade computation could be deferred until the end of the first week of the following quarter, to permit completion of the remaining one or two modules at the A-B mastery level.

With this system the student could proceed at his own pace and

walk into the final examination room with a minimum average of B, provided he made reasonable progress during the term in the completion of his module requirements.

Although most students opted for this mode of completing the course, not all students view such a system with favor. There are those who would rather take a few rigidly scheduled exams on a traditional sink-or-swim basis. In accordance with criterion no. 9, such provision was made. In fact, each student could elect a continuum of options between the pure competency-demonstration self-pacing mode and the traditional mode. With students registering for as many as five different subcourse versions in the same class and with the possibility of each student proceeding under some combination of self-pacing and classical examination modes, a CMI routine was ncessary. Such a computer code has been developed by the author and reduces the record keeping requirements to easily manageable proportions.

The cost-effectiveness of the system is analyzed in some detail below. Such systems require moderate levels of funding for student assistance. In particular, the updating and the maintenance of security on extensive quiz files and the logistics of individually assigning, monitoring, grading and recording quizzes places a heavy but not unreasonable burden on such funds. In times of financial retrenchment, however, it is not always possible to maintain reasonable levels of funding. Such is the case now. In response to increasingly severe budgetary restrictions which forced a cutback in student assistant staffing, it was necessary to first curtail and eventually eliminate the flexible-paced aspects of the system. The modular unit quizzes have been retained, but they are now scheduled on a weekly basis and

will not be repeatable. Thus, the system in adjusting to criteria no. 5 and no. 6 may lose some of its effectiveness in meeting criterion no. 2.

Cost Effectiveness

The development of cost effectiveness data within a give institutional setting is always subject to charges of prejudice. To transfer such data to other institutions is still more difficult. The data (table 2) on the per quarter cost of alternative systems of instruction is reasonably accurate for the University of Florida. During academic year 1972-73 two course sequences in engineering mechanics were offered - (ESM 304, 305 (10 hrs.) and ESM 301, 302, 303 (12 hrs.)). The data on faculty contact hours represent typical course scheduling patterns. If any error has been made, it has been in an underestimation of the AY 1972-73 student assistant expenditures. Data for the modular system are based on actual experience and budgeted expenses. No amortization of development costs is shown for the modular system because of the caprices to which such estimates are subject. If one assumes that one-third of a faculty line item/quarter on a continuing basis would be a reasonable allocation for the cost of development and modification, then that would add about $2000 to the indicated cost figures. The data for the austere traditional system would represent a severe cutback in service offered, since it would require all departments to take a common 12 hour course sequence. Such a development would meet with severe resistance and lead to possible loss of customers and the duplication of courses. It would offer no advantages.

Teaching Assistant Effectiveness

The one salient feature of the cost data of table 2 is the great increase in expense incurred by substituting graduate student assistants for undergraduate assistants.

At the end of the fall 1974 quarter the students were asked to evaluate the effectiveness of each of the teaching assistants. This was a quarter in which the students had extensive tutorial contact with teaching assistants. They were asked to respond to the following statements:

1) Had a good knowledge of the subject matter for this course.
2) Graded quizzes fairly.
3) Helped you learn the material.
4) Treated students courteously.
5) Overall effectiveness.

The average scores of the three graduate assistants are compared with those of the four undergraduate students in table 3. There is a consistent pattern of superior performance by the undergraduate students in comparison with the graduate students.

The differences may be attributable to a number of facts which are widely applicable to other institution. First, the graduate students were average graduate students in the department. They were not volunteers, nor were they specially selected by the instructor. They were available, were not working on reimbursable grants, and they were assigned to the teaching lab as part of their assistantship responsibilities. The undergraduate students were among the very best students in the college. They were recruited and there were more applicants than positions. Moreover, if called upon to work longer hours on occasion, they were pleased to do so since they were being paid by

the hour. The graduate students are paid a monthly stipend in return for which they may be called upon to perform some duties. It would be understandable if they felt that to some extent they were overworked and underemployed.

The differences in performance are not large, and one should not conclude that graduate students not be used for such assignments. Rather, it is safe to say that no loss of effectiveness occurs if undergraduate students are hired. It may be highly desirable to assign graduate students to such duties as a means of supporting the graduate program. Any increment in cost attributable to the use of graduate students, however, should be considered as part of the cost of the graduate program and not part of the cost of the undergraduate instructional system.

Effectiveness of the Instructional System

It would be felicitous to report evidence that the modular, flexibly paced instructional system results in superior student mastery of engineering mechanics in comparison with students educated by traditional methods. Although there is reason to believe this to be so, evidence for such a sweeping conclusion is difficult to produce. One cannot trust comparisons between performance on nominally comparable tests or even comparisons in performance on the same test graded by different people, or on the same test graded by the same person on two different occasions.

There are data to report, however, which tend to corroborate the improvement in student performance attendant to the use of the system described above. Table 4 shows the average grades on the final exams for six randomly selected courses taught under the modular system.

TABLE 4

FINAL EXAM GRADES OF RANDOMLY SELECTED MODULAR COURSES

Term	Course	"A" (0-7 quizzes passed)	"B" (8 or more quizzes passed)	Sample size	% Improvement ("B"-"A")x100 / 100 - "A"
F 73	ESM 301	47	63	52	30.2
W 74	ESM 302	54	68	23	30.4
S 74	ESM 303	53	56	49	6.38
F 74	ESM 301	84	91	34	43.8
F 74	ESM 302	48	47	27	-1.9
F 74	ESM 303	46	54	52	14.8

Total sample size = 237   Weighted average % Improvement = 20.2%

The students have been split into two groups. In column 'A' the final examination scores of students who completed 0-7 units prior to taking the exam are listed. In column 'B' similar results are shown for students who completed 8 or more units. The average number of required units for all courses is 9. The last column shows the percentage improvement as 100 times the ratio of the difference in scores divided by the maximum possible difference in scores. This figure of merit provides a common basis on which examinations with different mean scores may be compated.

During the spring 1975 quarter large numbers of students took the major in-class examinations for the first time. Similar results for these courses are tabulated in table 5.

TABLE 5

AVERAGE GRADE ON 4TH WEEK EXAM, SPRING 1975

Courses	No quizzes passed	Some quizzes passed	All quizzes passed	Sample size	% Improvement Some quizzes passed	% Improvement All quizzes passed
ESM 301	66	75	90	134	26.5%	70.6%
ESM 302	59	63	79	70	9.8%	48.8%
ESM 303	69	76	88	88	22.6%	61.3%

Total sample size = 292
Weighted average
% Improvement, some quizzes passed: 21.3%; all quizzes passed: 6.3%

Tables 4 and 5 show that participation in the competency demonstration quiz program results in significantly improved performance on the comprehensive final exams and on the comprehensive fourth week exams, although the data indicate that the effect is less pronounced in the final examination, which covers a larger amount of material and longer time span.

There is a possibility that the data are misleading, in that the students who complete the units may be better students and that this factor may account for the observed improvement. To test this hypothesis the data for the large spring 1975 statics class were examined in more detail. Table 6 shows the examination results for students who passed varying numbers of quizzes prior to the examination. The third column shows the average GPA for each of these groups of students. The consistent GPA trend suggests the possibility that the

TABLE 6

EXAM RESULTS FOR STUDENTS PASSING VARYING NUMBERS OR PRIOR QUIZZES

Number of quizzes passed	Average grade on examination	University grade point average	GPA corrected examination grades
0	66	2.74/4.0	66
1	73	2.84/4.0	71
2	80	2.87/4.0	78
3	90	3.09/4.0	86

improvement in examination scores may be due to the fact that better students pass more of the quizzes. However, when the GPA for each of these groups was reduced to the base 2.74/4.0 level by randomly deleting from the data set a sufficient number of students with high GPAs, it was found that examination scores for the student with comparable GPAs, but different numbers of quizzes passed, were markedly different. Participation in the competency quiz program accounted for 20 points of the 24 point grade spread observed.

Thus, one may conclude that students with comparable histories of academic achievement performed better by participating fully in the use of the procedures and materials in this instructional system. To this conclusion a skeptic might respond --what's new? All that has been shown is that students who work hard do well. While to a degree such criticism is justified, the data do indicate some useful information, e.g., the tasks assigned to the student are relevant to the

objectives and effective in meeting them. While one may intuitively anticipate such a conclusion, it is nonetheless not trivial. Without experimental verification, an engineering professor may be no more certain that completion of certain exercises will contribute to the mastery of a given subject than may a swimming coach be certain that completion of a regimen of calisthenics will increase the speed of his swimmers.

Conclusion

As a result of experience with the modular system during academic years 1973-74 and 1974-75, its feasibility has been demonstrated. It is competitive on a cost basis with conventional systems, and preliminary results indicate that student performance may be improved by the use of the instructional materials and procedures of this system. Course evaluation questionnaires and informal consultation with students and teaching assistants indicate positive affective response to the system and a belief by the students that they are learning more than they would have in more conventional systems. Attempts to make a more definitive evaluation of system effectiveness are in progress. However, it is clear now that by using the modular structure, the departments served by the courses have more detailed knowledge and control of the content of the material for which their students are responsible.

APPENDIX B

STUDENT RECORD SHEET

APPENDIX B

STUDENT RECORD SHEET

NAME ____________________

SS# ____________________ Quarter ____________

Course: ESM 30 ______ Credits ______ ____________ Subcourse Version

Major Department ____________________

U.F. G.P.A. ____________ Hours Registered This Quarter ____________

If working, how many hours ____________?

Lower Division Preparation at: UC ____________________
Community
College (which) ____________________

Other ____________________

Highest Math Completed ____________ PS 215 Grade ____________

ESM 301 Grade ____________ When ____________

UNIT	SCORE	DATE	UNIT	SCORE	DATE

EXAM	SCORE
I	
II	
Final	

APPENDIX C

SAMPLE MODULE PROFICIENCY TEST

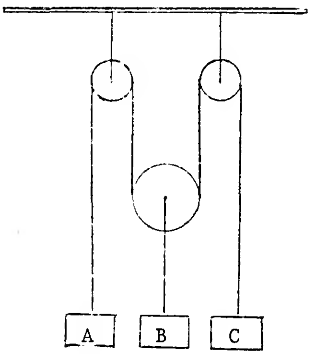
APPENDIX C

SAMPLE MODULE PROFICIENCY TEST

(1 hr - Closed Book - Table of Integrals Permitted)

1. A particle moves with an acceleration $a = -ks$ where k is a known positive constant. At time $t = 0$, $s = 0$; at time $t = 0$, $v = v_o$. Find the position as a function of time.

2. Block A is moving vertically upward at a constant speed of 10 fps. Block B starts from rest and accelerates downward with constant acceleration of 5 feet per second. At time $t = 0$ blocks A, B, and C are all at the same height. Calculate the velocity and acceleration of block C with respect to A at time $t = 1$ sec.



APPENDIX D

TABULATION OF OVERALL MODULE DIFFICULTY

TABLE 10

TABULATION OF OVERALL MODULE DIFFICULTY

Module	Initial Attempt	Initial Failure	Percentage
1	110	17	15.5
2	114	32	28
3	114	19	16.5
4	115	76	66
5	110	38	34.5
6	115	40	35
7	80	28	35
8	107	43	40
9	90	13	14.5
10	40	11	36
11	41	7	17
12	39	11	28
13	40	11	27.5
14	39	21	54
15	36	16	44.5
16	34	18	53
17	32	14	44
18	36	8	22
19	*		
20	*		
21	*		
22	71	16	22.5
23	73	10	14
24	72	5	7
25	71	10	14
26	71	20	27
27	63	15	24
28	65	16	24.5
29	73	10	14
30	66	18	27
31	14	5	36
32	16	1	6
33	9	0	0
34	*		

*Seldom used

APPENDIX E

TABULATION OF END-OF-MODULE PROFICIENCY TEST DIFFICULTY WITHIN EACH MODULE

TABLE 11

TABULATION OF END-OF-MODULE PROFICIENCY TEST
DIFFICULTY WITHIN EACH MODULE

Module	Initial Attempts	Initial Failures	%	Module	Initial Attempts	Initial Failures	%
1-1	14	1	7	6-1	15	3	20
1-2	11	0	0	6-2	12	6	50
1-3	12	1	8	6-3	12	5	41.5
1-4	10	4	40	6-4	11	3	27
1-5	14	1	7	6-5	11	5	45.5
1-6	8	2	25	6-6	9	2	22
1-7	12	4	33	6-7	9	4	44.5
1-8	4	1	25	6-8	14	6	43
1-9	14	2	28.5	6-9	11	5	45
1-10	11	1	9	6-10	11	1	9
2-1	20	2	10	7-1	7	4	57
2-2	31	7	22.5	7-2	5	2	40
2-3	26	11	42	7-3	*		
2-4	24	8	33	7-4	8	3	37.5
2-5	13	4	31	7-5	13	3	23
				7-6	11	5	45.5
3-1	23	2	9	7-7	9	2	22
3-2	22	4	18	7-8	10	3	30
3-3	26	4	15.5	7-9	8	2	25
3-4	22	4	18	7-10	6	3	50
3-5	21	5	24				
4-1	7	1	14	8-1	16	12	75
4-2	15	14	93.5	8-2	15	4	27
4-3	15	5	33	8-3	10	5	50
4-4	17	9	33	8-4	10	4	40
4-5	15	13	87	8-5	7	2	28.5
4-6	12	6	50	8-6	12	2	17
4-7	17	9	53	8-7	11	7	64
4-8	6	6	100	8-8	7	2	29
4-9	*			8-9	12	4	33
4-10	8	5	62.5	8-10	7	1	14
5-1	11	3	27	9-1	12	0	0
5-2	5	3	60	9-2	12	1	8
5-3	11	6	54.5	9-3	6	3	50
5-4	10	3	30	9-4	13	3	23
5-5	11	4	37	9-5	19	2	10.5
5-6	10	3	30	9-6	8	2	25
5-7	10	2	20	9-7	8	1	12.5
5-8	10	3	30	9-8	9	0	0
5-9	16	9	56	9-9	*		
5-10	16	2	12.5				

TABLE 11 - continued

Module	Initial Attempts	Initial Failures	%	Module	Initial Attempts	Initial Failures	%
10-1	18	0	0	18-1	11	2	18
10-2	10	1	10	18-2	5	1	20
10-3	7	3	43	18-3	7	2	29
10-4	5	4	80	18-4	6	1	33
10-5	10	3	30	18-5	7	2	29
11-1	8	2	25	19 *			
11-2	6	1	17				
11-3	12	2	17	20 *			
11-4	4	1	25				
11-5	11	1	9	21 *			
12-1	10	1	10	22-1	14	1	7
12-2	7	1	14	22-2	18	6	33
12-3	6	2	33	22-3	11	4	37
12-4	8	4	50	22-4	13	2	15
12-5	8	3	37.5	22-5	15	3	20
13-1	6	1	17	23-1	15	2	13
13-2	11	0	0	23-2	16	2	12.5
13-3	10	4	40	23-3	13	1	77
13-4	7	4	57	23-4	15	2	13
13-5	6	2	33	23-5	14	3	21
14-1	7	5	71.5	24-1	16	2	12.5
14-2	8	8	100	24-2	15	0	0
14-3	6	1	17	24-3	19	1	53
14-4	10	3	30	24-4	14	0	0
14-5	8	4	50	24-5	8	2	25
15-1	10	6	60	25-1	11	2	18
15-2	5	1	20	25-2	11	3	27
15-3	6	1	17	25-3	11	1	9
15-4	7	5	71.5	25-4	10	1	10
15-5	8	3	37.5	25-5	9	1	11
				25-6	12	0	0
16-1	9	5	55.5	25-7	7	2	29
16-2	8	7	87.5				
16-3	6	2	33	26-1	14	5	36
16-4	6	2	33	26-2	5	1	20
16-5	5	2	40	26-3	9	4	44.5
				26-4	8	3	37.5
17-1	7	3	43	26-5	7	1	14
17-2	8	3	37.5	26-6	8	4	50
17-3	6	1	17	26-7	6	0	0
17-4	6	2	33	26-8	9	2	22
17-5	5	5	100	26-9	5	0	0

TABLE 11 - continued

Module	Initial Attempts	Initial Failures	%
27-1	12	2	17
27-2	11	0	0
27-3	13	5	38.5
27-4	11	1	9
27-5	16	7	44
28-1	17	6	35
28-2	12	3	25
28-3	14	2	14
28-4	14	4	28.5
28-5	8	1	12.5
29-1	11	1	9
29-2	9	1	11
29-3	13	3	23
29-4	13	2	15.5
29-5	11	1	9
29-6	16	2	12.5
30-1	14	6	43
30-2	15	3	20
30-3	14	4	28.5
30-4	11	2	18
30-5	12	1	8
31-1	*		
31-2	4	3	75
31-3	*		
31-4	*		
31-5	4	0	0
32-1	4	1	25
32-2	4	0	0
32-3	5	0	0
32-4	*		
33*			
34*			

* = 3 or fewer occurrences

APPENDIX F

SELECTION OF STUDENT RECORDS FOR THE DATA BASE

APPENDIX F

SELECTION OF STUDENT RECORDS FOR THE DATA BASE

The researcher found that the records of many students could not be used.

A student not taking the standard version of a course could not be pooled with those who were because module difficulty varied and occasionally because the number of modules varied. The researcher selected ESM 301 Version 10, ESM 302 Version 20, and ESM 303 Version 30 as the most common versions. They also each contained nine modules. Students not taking these versions were not initially included in the data base. As described in Chapter IV, to increase the usable population of the ESM 301 sections, Version 11 was included later. This was done by disregarding the Module 7 information of Version 10 so that both versions became identical and could be combined as eight-module versions.

Each student had the option of taking two intracourse examinations in lieu of taking the modular version. Students could select the examination path initially or during the quarter. Students falling behind in the modules often changed to the examination path by choice or by requirement of the professor. Furthermore, some students were dropouts. The only information available from the student record sheet for all these cases was an incomplete record of module test results. Students not pursuing the modular route to completion were not included in the data base. The fact that a nonmodular option existed means that those students who were included in the data base did not represent the entire student body of the College of Engineering or a randomly selected portion of it. The two above reasons caused a sizeable loss of student names during the initial data selection.

Subsequently, various reasons caused other students to be deleted from the data base. Occasionally the handwriting of student assistants was indecipherable. A loss of a student for this reason was considered to be a random occurrence not introducing a bias.

In calculating the modified junior year grade-point average for those students having completed a useable version, several specifications were used to eliminate students whose matriculation was distinctly different from the majority. The object was to reduce dispersion by increasing homogeneity. Most often the reason for eliminating a student from the data pool was that he was late in taking the ESM junior level courses. All students who were classified as seniors or graduate students at the time of starting ESM 301 were excluded. Students who began ESM 301 early in their sophomore year were also excluded. Reviewing transcripts of the students revealed various other unusual conditions such as having gaps between taking the ESM courses or taking ESM 303 before 302. A few extreme cases were eliminated. A few students were eliminated because their transcript record of nonmodularized courses (used for calculating the modified junior year GPA) totaled less than 20 quarter hours during the quarters in which they took the ESM courses.

A student whose transcript was not included in the special extracting of transcript records by the Office of the Registrar was deleted from the data pool. The modified junior year GPA could not be established for those students.

A few of the then remaining students were found to have not taken the final examination. They were deleted because for them there was no value of the dependent variable.

A few sections were not included because the student folders were not obtained. One section was lost from the data base because the professor had not retained the computer printout showing the final examination score. This is the dependent variable of this experiment. This data was not recorded on the student record sheet maintained by student assistants.

One section was deleted from the data base by the researcher because the final examination average was 93% with half the individual grades being 100%. This data provided an unusual distribution of the dependent variable.

Several sections of ESM 302 and 303 were not included because the usable number of students was undesirably small and other larger sections of the courses were available for moderate representation of these courses to be included in the research.

In summary it seemed to the researcher that he was continuously being confronted with decisions as to what data was usable. Both homogeneity and large numbers were needed to improve chances of obtaining a statistically significant finding. The more carefully student records were examined, the more difficult it was to find homogeneity. With data coming from the written record of several student assistants, several professors, and the registrar, missing bits of information occurred and caused the loss of students from the data base. The large number of students who took the courses during the six quarters that unlimited no-penalty retaking feature was in effect permitted the researcher to be selective. Ten sections of the modularized courses produced usable populations for statistical analysis.

APPENDIX G

TWO DIMENSIONAL PLOTS OF THE DATA FROM SELECTED SECTIONS

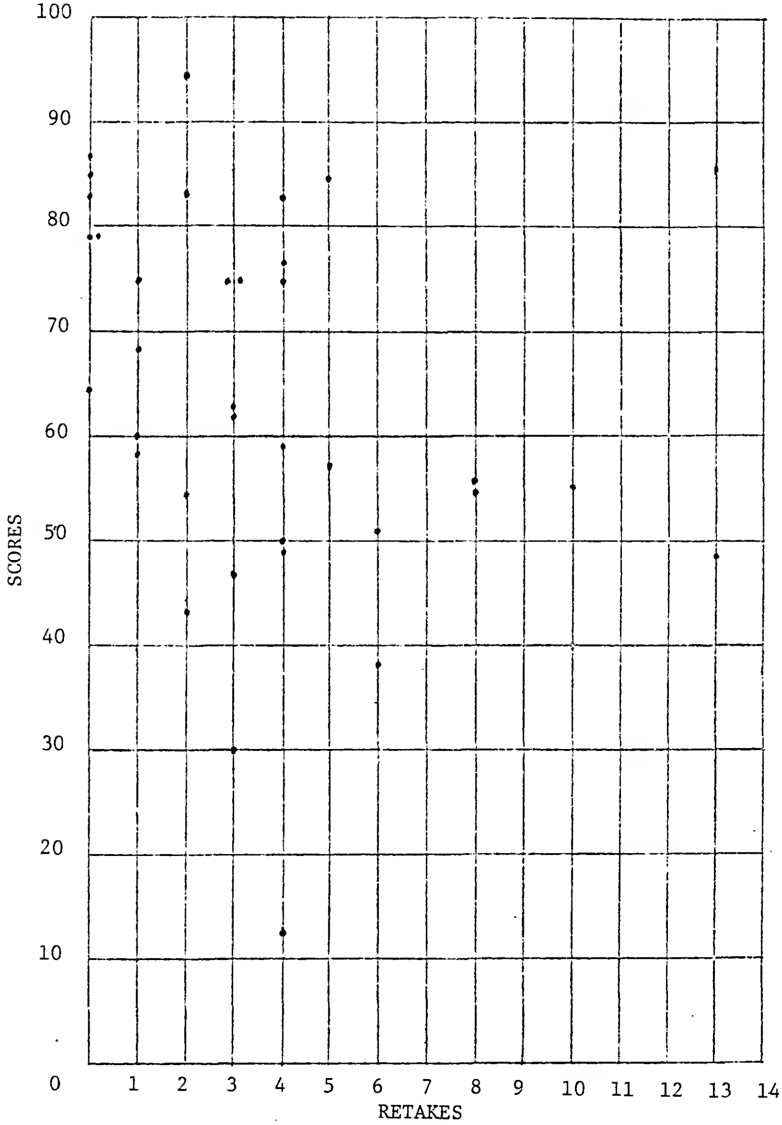


Figure 1

SCORE VERSUS RETAKES FOR SECTION 1

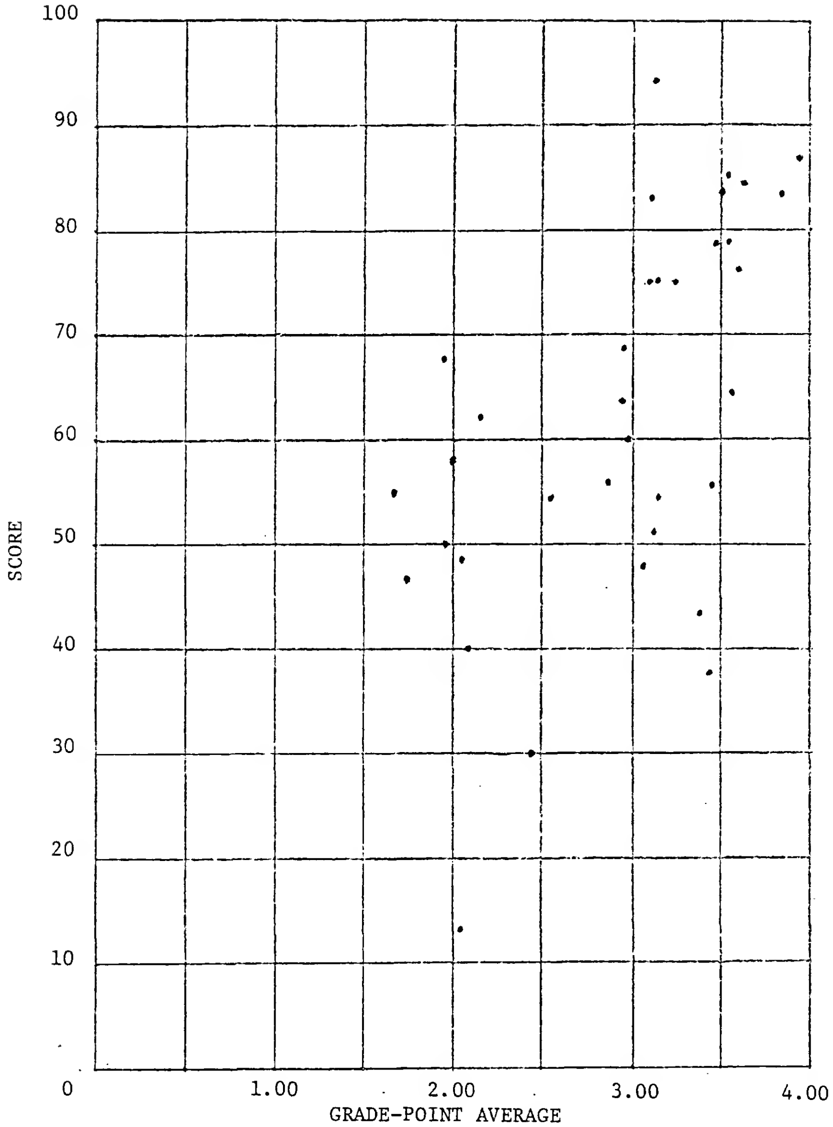


Figure 2

SCORE VERSUS GPA FOR SECTION 1

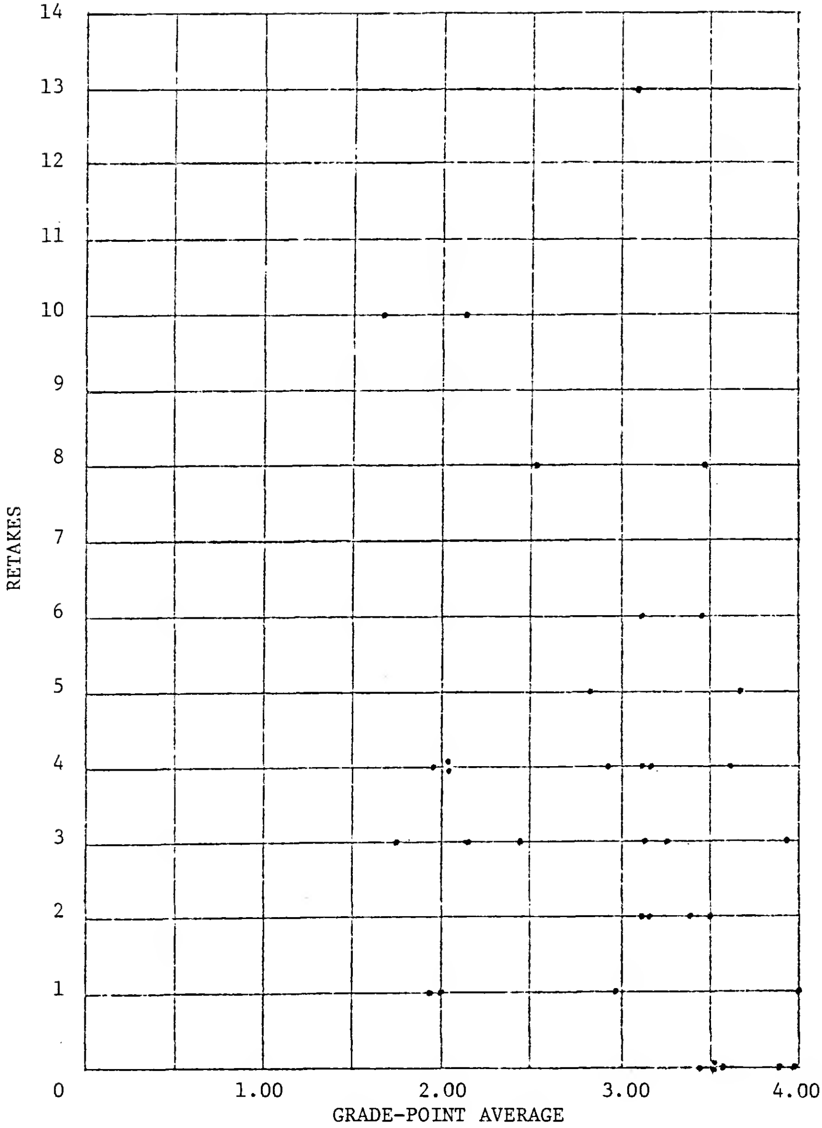


Figure 3

RETAKES VERSUS GPA FOR SECTION 1

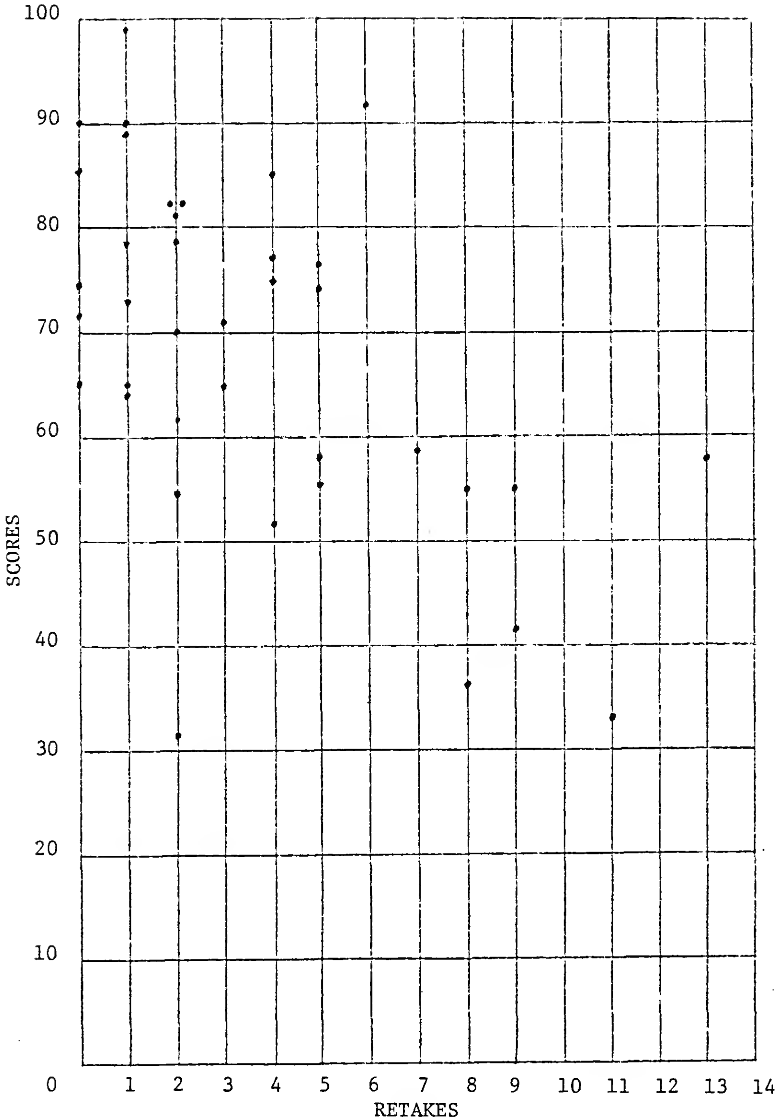


Figure 4

SCORE VERSUS RETAKES FOR SECTION 2

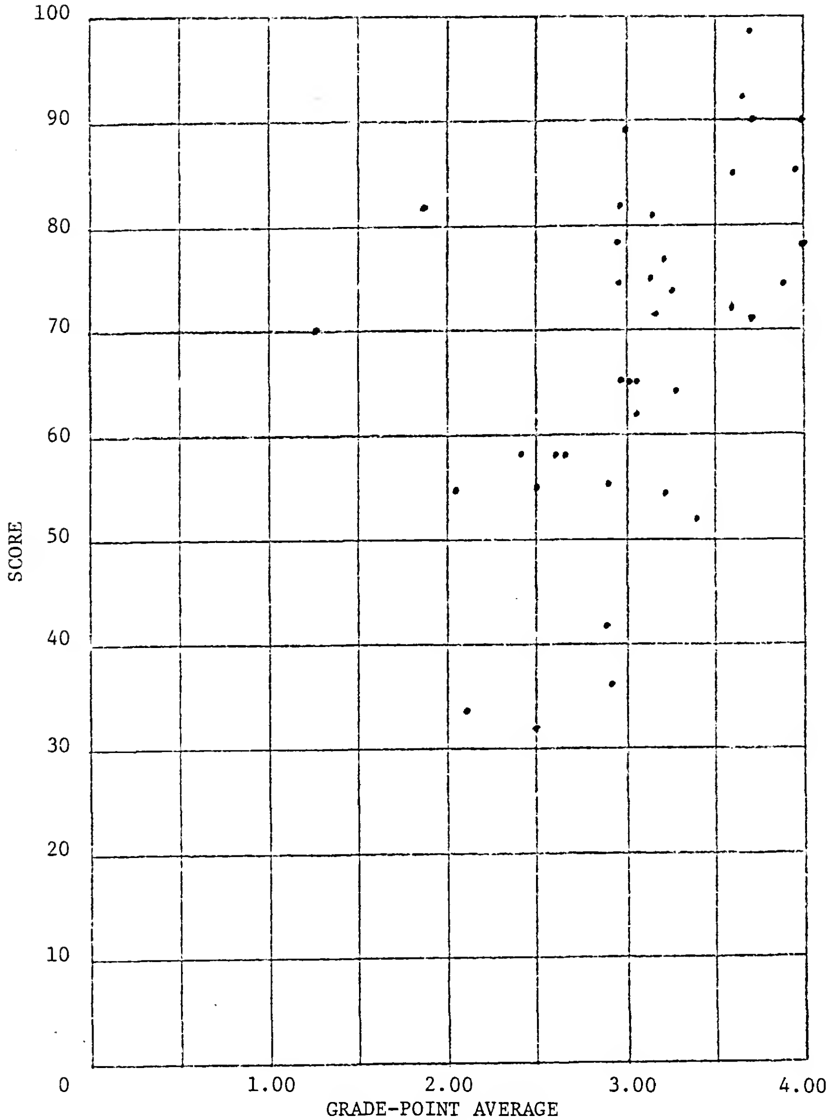


Figure 5

SCORE VERSUS GPA FOR SECTION 2

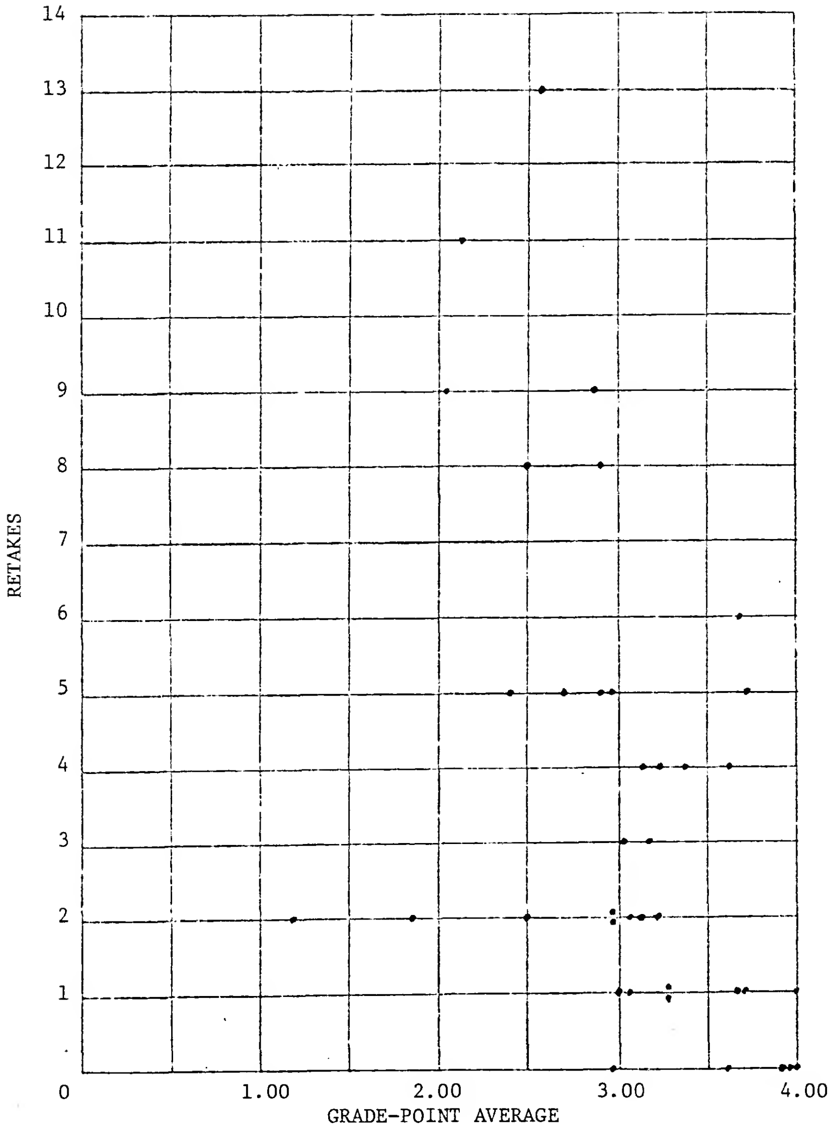


Figure 6

RETAKES VERSUS GPA FOR SECTION 2

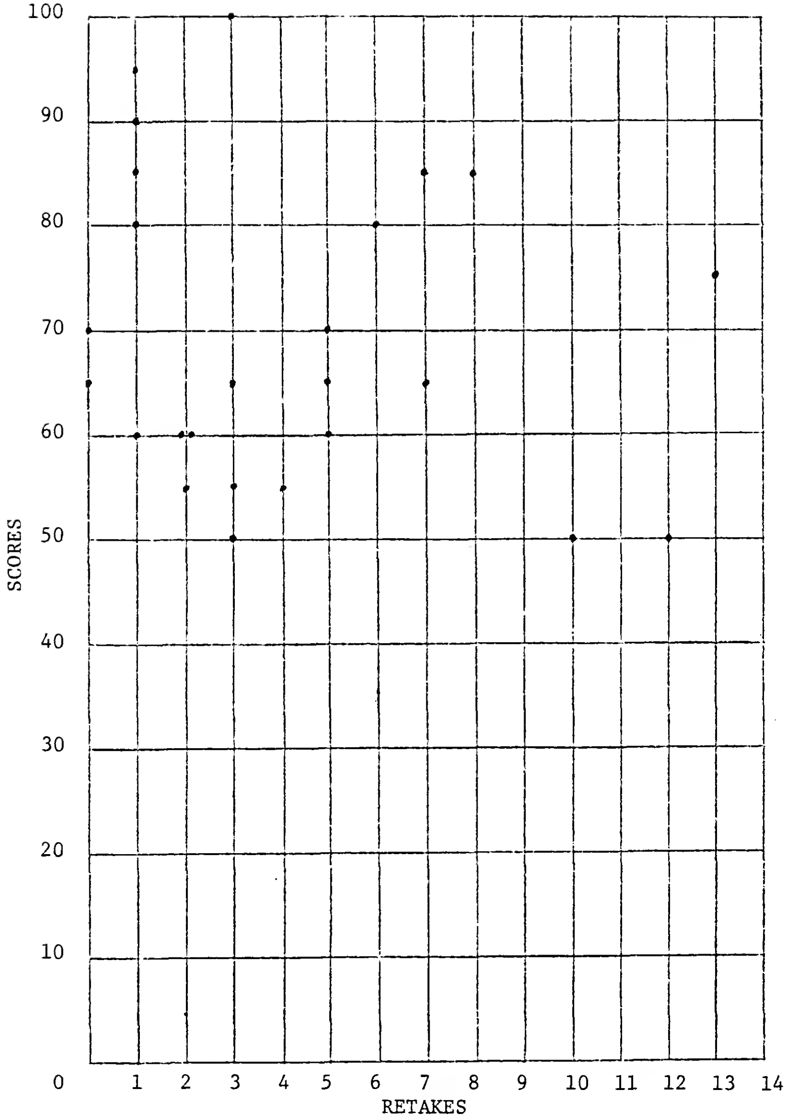


Figure 7

SCORE VERSUS RETAKES FOR SECTION 3

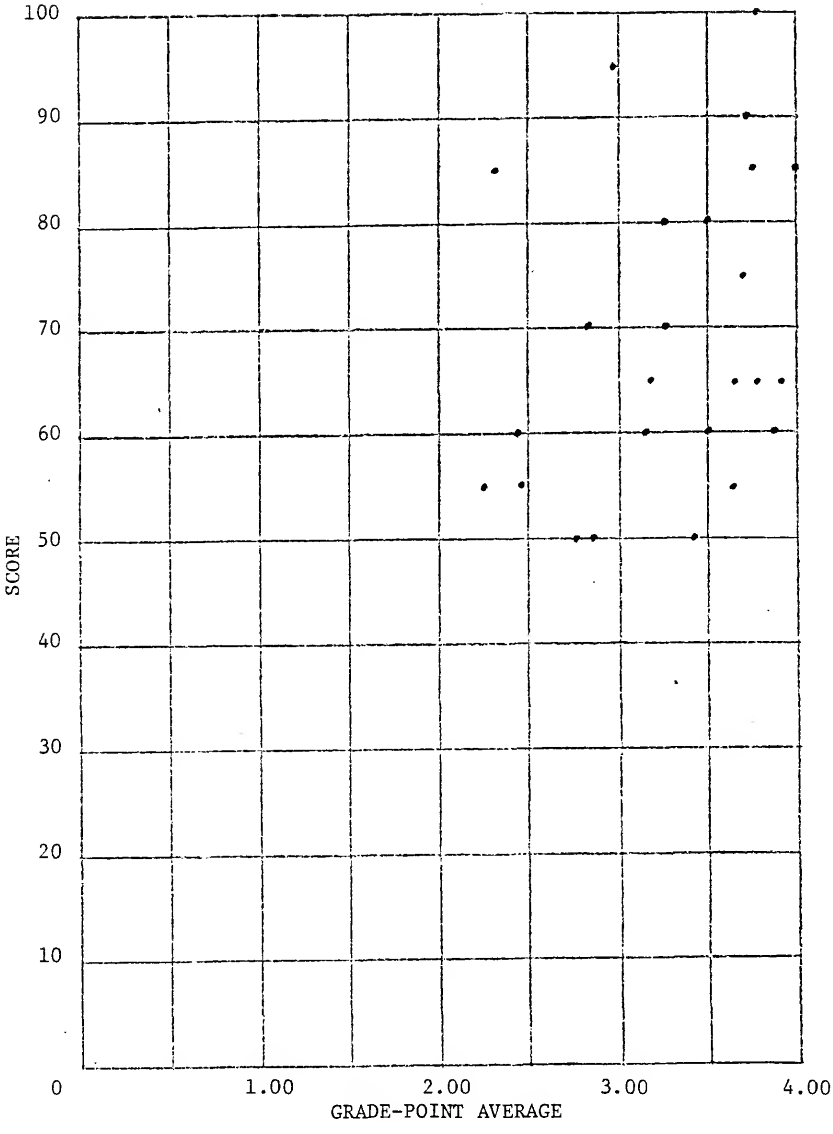


Figure 8

SCORE VERSUS GPA FOR SECTION 3

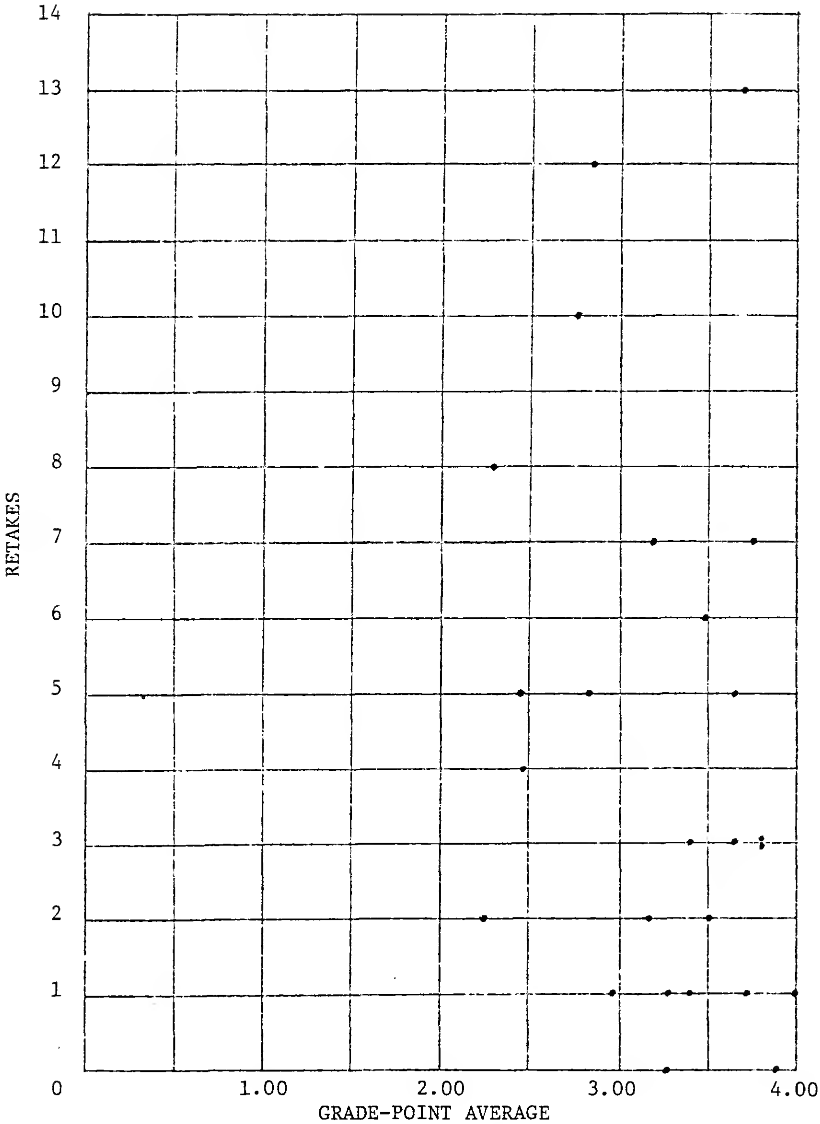


Figure 9

RETAKES VERSUS GPA FOR SECTION 3

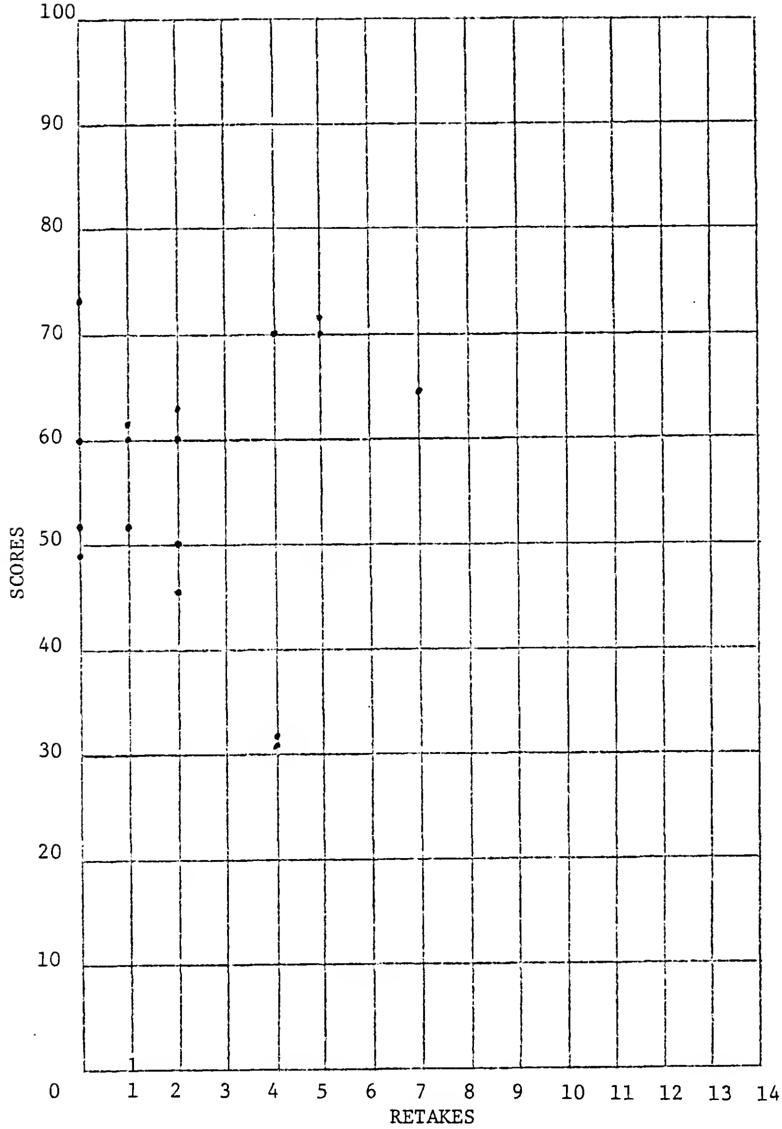


Figure 10

SCORE VERSUS RETAKES FOR SECTION 9

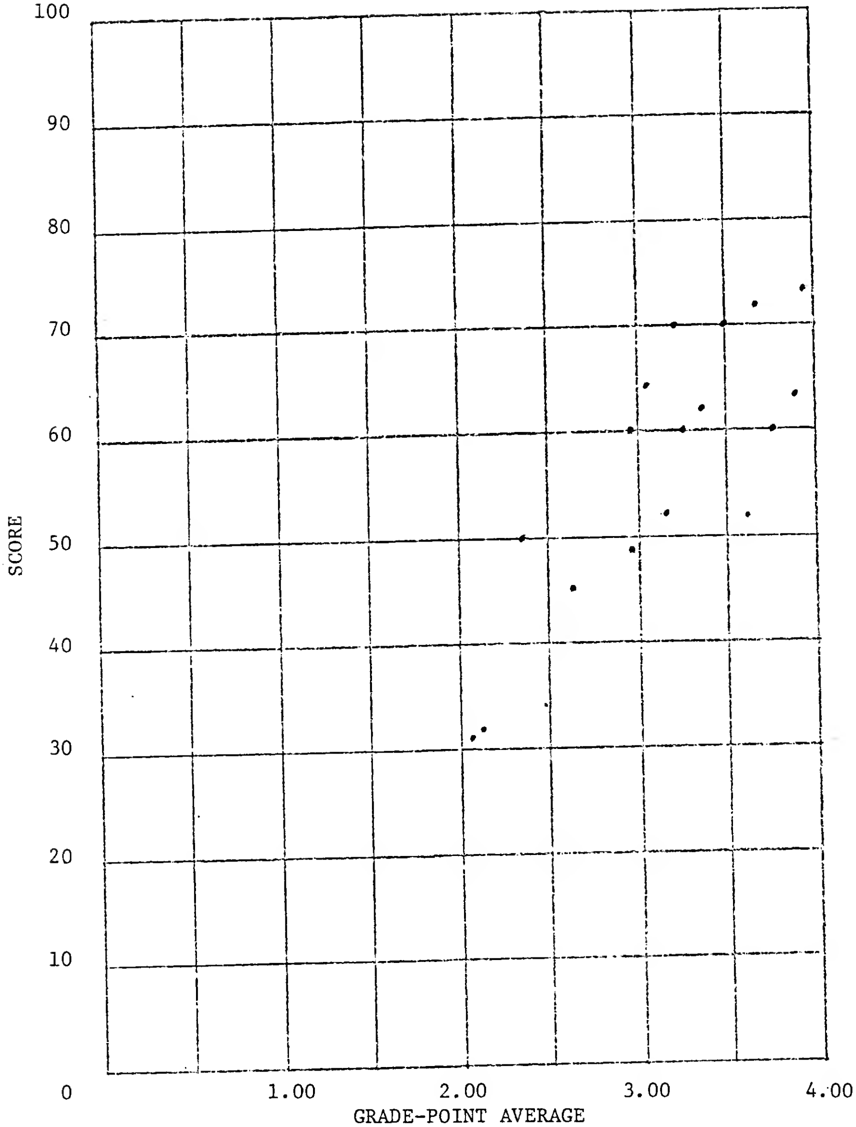


Figure 11

SCORE VERSUS GPA FOR SECTION 9

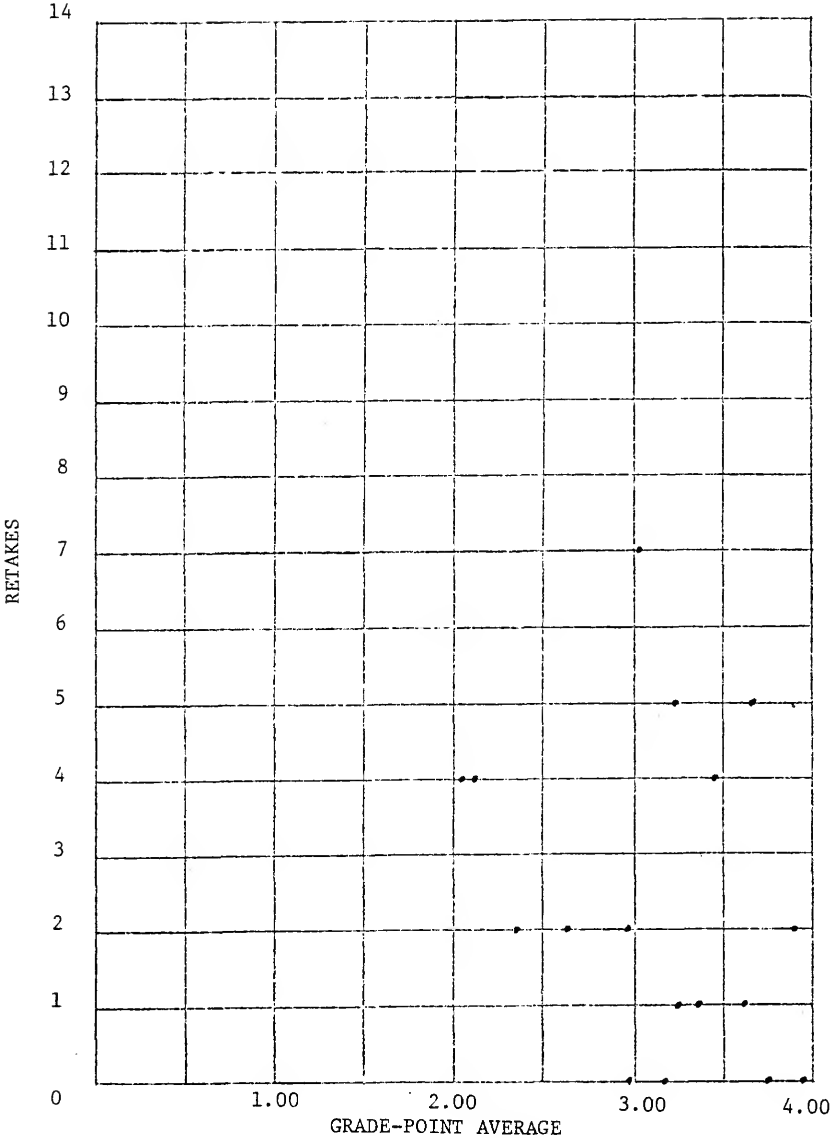


Figure 12

RETAKES VERSUS GPA FOR SECTION 9

APPENDIX H

STUDENT ATTITUDE QUESTIONNAIRE

APPENDIX H

STUDENT ATTITUDE QUESTIONNAIRE

Dear ESM Student:

I am a recent College of Engineering graduate assistant. I'm now doing an independent survey regarding teaching methods. Please tell me how you feel about the innovations you have experienced in the engineering mechanics course. Please include your name so I can add data from the module completion records lab and do a statistical analysis. THIS QUESTIONNAIRE WILL NOT BE SEEN BY THE FACULTY. Thank you.

William Doby
5811 Atlantic Blvd. Apt. 16, Jacksonville, FL 32207

1. How important is mastery of this subject matter to your career?

   Great _____ Moderate _____ Little _____

2. How much did you like the self-pacing feature of this course as compared to the prescribed pacing of a lecture-examination course?

   Strongly Prefer _____ Prefer _____ No Preference ____ Dislike___

3. Do you feel that the modular organization helped you learn engineering mechanics better than the usual organization would have?

   Definitely _____ Probably _____ No Opinion _____ No _____

4. Do you feel your overall career objectives were better met because this course was not taught in the traditional manner?

   Much Better _____ Better _____ No Difference _____ Poorer _____

5. How enthusiastic was your professor for this new approach?

   Enthusiastic _____ Average _____ Unenthusiastic _____

6. How would you like your next engineering course to be organized?

   Traditional _____ Self-Paced Modular _____ No Preference _____

7. How would you like <u>all</u> your engineering courses to be organized?

   Traditional _____ Self-Paced Modular _____ No Preference _____

The thing I liked most was . . .

The thing I likes least was . . .

I suggest . . .

Name ________________________________

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BIOGRAPHICAL SKETCH

The researcher, otherwise known as Bill, is married to Marcia. Ann, who was born in 1975 is their first child. They hope Ann will have a little brother or sister after Bill has other things to do besides his dissertation.

William Clifford Doby was born in Atlanta in March 1926. He grew up there and had almost completed his sophomore year in chemical engineering at Georgia Tech when he joined the Navy in 1944.

Following World War II, he attended the Naval Academy for four years and received the B.S. in 1949.

Following the Korean War, he attended the Naval Postgraduate School for two years studying engineering electronics and received the B.S. in 1956. For the following two years while on shore duty, he took (half-time) liberal arts courses at William and Mary in Norfolk (now Old Dominion).

Following the Viet Nam War he retired from the Navy in 1968, and moved to Jacksonville, Florida, and began teaching high school mathematics. He did not like high school teaching and began teaching electronics at Florida Junior College in 1969. He likes community college teaching.

After three summer sessions at Rochester Institute of Technology, he received the M.S. in engineering technology in 1972.

At this time he accepted with much appreciation a Graduate Council Fellowship to attend the University of Florida and received the Ed.S. degree in 1973. Bill is a conservative type. He didn't fully realize this until he associated with the activists at the big campus in Gainesville, Florida.

He continued full-time study in the College of Education during 1974 and became a candidate for the Ph.D. Meanwhile, he enjoyed being a graduate assistant in the College of Engineering.

He is presently teaching engineering technology courses at Florida Junior College.

Bill advocated continuing education. But having been a college or military school student for more than half of the last 33 years, he has had enough as of the summer of 1976. He won't stop growing, but he suggests to anyone reading this far that there are other things besides the cognitive domain and that he and the reader should go have a fling in those other domains. Bill plans to be a husband and father while at the same time increasing his skills around the homestead in plumbing, carpentry, and cooking. Marcia and Ann come first.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James W. Hensel, Chairman
Professor of Curriculum and Instruction

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Martin A. Eisenberg
Professor of Engineering Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert A. Ramey
Professor of Electrical Engineering

This dissertation was submitted to the Graduate Faculty of the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August, 1976

Dean, College of Education

Dean, Graduate School

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